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Composing abstractions? General musical
behaviours in five new works for humans and
computer

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- PhD Creative Music Practice
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Abstract

This written thesis supports a portfolio of composition work. This portfolio was composed to study ‘music systems’ - things that I intentionally design in order to make music happen in future. As a composer of works for computers and humans, music technology is an inherent requirement of my practice. However, I have noticed a tendency to spend a lot of time working on the technological components of these systems, but little time making music. It is easy to conflate the task of composing music with the process of using technology. I argue that this is a matter of ‘analytical framing’. A purely technological framing of what music is, and how it can be worked on, is clearly reductive. To present experiment with different framings, I identify a set of systems that were used to compose my portfolio and ask what they are made of. I produce technical, temporal, communicative, social and ethical answers to this question; each of these new analytical framings respectively unpacked in a specific chapter of this thesis. This reveals that my compositional practice, as a total structure made manifest through the content of my portfolio, can be framed as a complex music system in itself. Crucially, this system is populated by general musical behaviours that are consistent across multiple different framings of what my practice is. My primary argument is that interesting things happen when these abstract behaviours are identified, sorted and instantiated into new works of music. As a contribution to contemporary music discourse, my portfolio documents a novel set of approaches to working with music and systems. From a theoretical standpoint, my multi-framed definition of ‘music system’ helps sidestep a commonly encountered problem in electronic music studies: an over-fixation on technicity which elides social and cultural context. Moreover, this project helps in-grain a practice-orientated understanding of music systems design, by concluding that music systems exist most significantly (i.e. most practically) as iterative, playful and emergent processes of modulating sound perception through time.

My title

List of Figures	3
acknowledgements	4
lay summary	5
introduction	7
five new works	8
core argument	9
structure of this thesis	12
contribution	15
methodology: mess, spirals and iteration in practice-led research	21
mess	22
spirals	25
iteration	28
music systems as practice-led research	31
three core definitions	33
cybernetics as a contemporary music practice	34
music and analytical framings	35
abstraction as information compression	37
chapter 01: can I treat a person like a software patch?	39
section 01: 'solo guitar as a MaxMSP patch' (2019)	40
section 02: the piece as a performance system	45
section 03: presets as abstractions	51
chapter 02: how are clocks embedded into music systems?	55
section 01: 'transaction history' (2018)	56
section 02: a soundmap of a bitcoin transaction	59
section 03: clocks as abstractions	67
chapter 03: assimilation or dissimulation? a sociotechnological feedback study	72
section 01: 'assimilation/dissimulation' (Mastrantonis & Walker, 2019)	73
section 02: a feedback loop between two composers	77
section 03: feedback loops as abstractions	84
chapter 04: how are social relations embedded into music systems?	90
section 01: 'assembly lines' (2020)	91

section 02: a network of social interactions	94
section 03: social relations as abstractions	99
chapter 05: can I treat a software patch like a person?	104
section 01: 'egregores' (2020-2022)	105
three studies of agency and ethical value	109
section 03: 'ethics as abstractions'	118
conclusion	123
five framings of my compositional practice	124
a livelier interpretation of my primary argument	127
References	130
Appendix A - electronic sound techniques	135
gutter synthesis	136
corpus based concatenative synthesis	137
FFT freezing	138
Appendix B - Assimilation / Dissimulation - statement on collabora- tion - Jack Walker	139
Appendix C - Artist Statement- Aggelos Mastrantonis: Assimila- tion/Dissimulation	141

List of Figures

1	A visual map of Middleditch and Schwartz as an approach to improvisation	42
2	A visual map of Murderville as an approach to improvisation	42
3	How the piece is played in performance	45
4	The piece as formed by a complex network of interactions	47
5	A feedback loop	50
6	A sonic map of a bitcoin transaction	59
7	Chronological map of a bitcoin transaction	62
8	Social map of a bitcoin transaction	63
9	A more complex map of this mapping process	66
10	A diagram of how the piece was formed	74
11	A representation of the software interface	78
12	A representation of the piece as a performance system	80
13	A diagram of how the Phase 01 system functioned	95
14	A diagram of how the Phase 02 system functioned	97
15	Agency study 01: feedback loop with envelope follow	110
16	Agency study 03: feedback loop with envelope follow and gutter synth	111
17	Agency study 02: feedback loop with envelope follow and concatenative synth	112

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lay summary

This doctoral project was carried out to learn more about ‘music systems’. For the context of this research, I (loosely) define these systems as things that can be used in order to ensure the possibility of musical experience. While this definition would include hi-fi systems, Spotify or concerts promotion, the specific systems that I am interested in primarily involve ‘live’ music: they are things that are intentionally used in order to enable the performance of music by musicians. As a practice-based investigation, the systems that I foreground are things that I have made myself. It is important to note that the majority of practical work carried out for project falls into the context of electronic music studies. Simply put, I describe this type of musical activity as approaches that fixate upon using loudspeakers as a core means of generating musical material. This can include ‘fixed media’ electroacoustic concert works that are played to audiences via a storage medium such as a CD, tape or audio file, or ‘live electronics’ pieces, where performers interact with technology (synthesisers, computers, microphones) in order to manipulate the expression of sound by loudspeaker.

While all components of my portfolio share this common fixation, the pieces that I have made are quite radically different from one another. My portfolio features: a live improvised performance on electronic guitar (still counted as ‘electronic’ due to the use of a guitar amplifier and PA system); a fixed media electroacoustic work; a scored work for ensemble and live electronics (composed with my friend and colleague Aggelos Mastrantonis); an ensemble improvisation mediated via the internet; and an EP of short semi-improvised pieces for ensemble and live electronics. Despite this variety, there is a significant degree of overlap between the different systems that I designed in order to make the music happen. As these general features are commonly found throughout my portfolio, I argue that they exist as redundancies: reoccurring elements that are consistent across multiple framings of my music as practice. I use this thesis to better understand what these redundancies are, in order to further my understanding of what it means to compose music by designing systems.

This isn’t a matter of semantics – I am not particularly interested in establishing a watertight definition of ‘music system practice’, to explain away and theoretically

model the behaviour of other musicians who intentionally use systems. I, however, am deeply interested in the components of my systems that consistently appear throughout my portfolio as a whole: elements of system design that are seemingly ubiquitous to my approach to making music by making systems. I refer to these things as abstractions: general features that will invariably haunt any specific example of my approach to making music. This set of uninvited (I never intended to find these things) and seemingly ever-present materials is fascinating to me, as I ultimately conclude that they comprise core elements of my music practice as a whole. This leads me to conceptualise my music practice as a music system in itself: a higher-level and general container to mediate the production of lower-level and specific musical experiences. A more thorough understanding of this system - as achieved through intuitive and reflexive practice - better enables me to design things that I like to hear.

introduction

“(M)usic has no material essence but a plural and distributed material being...music’s multiple simultaneous forms of existence — as sound, score, discourse, site, performance, social relations, technological media — indicate the necessity of conceiving of the musical object as a constellation....Compared with the visual and literary arts, then, music has to be grasped as an extraordinarily complex kind of cultural object — as an aggregation of sonic, visual, discursive, social, corporeal, technological, and temporal mediations” (Born, 2017, p. 44).

As practice-led research, this text supports a portfolio of composition. This set of five works was composed to study ‘music systems’: things that I intentionally design in order to make music happen in a particular way. This study can be broadly contextualised alongside musical cybernetics (Pickles, 2016); ‘the performance ecosystem’ (Waters, 2007), plus associated practical/analytical approaches (particularly Di Sciopio, 2003; Green, 2008, 2013, 2014); improvisation studies (Bailey, 1993; MacDonald & Wilson, 2020); and artificial intelligence and musical creativity (Born, 2021; Gioti, 2020, 2021; Walker, 2019, 2020, 2021b). My primary motivation is fairly simple: as someone who composes music by designing systems, I want to enjoy the way that these things behave. To this end, I have created five systems, each one corresponding to a work in my portfolio. Crucially, each of these systems was designed in a very different way to each of the others. It is relevant to note that, despite this plurality, certain things repeatedly cropped up throughout this process: system behaviours that consistently appeared (as positive features) regardless of the specific musical context. I argue that that these general musical behaviours - or *abstractions* - hold some significance to me as a composer: they are exactly the sort of things that I want my music systems to do. In this *Introduction*, I give an overview of my portfolio, then set out my research problem and primary findings, followed by an account of this work’s contribution to new music research. I follow with a rundown of my main body chapter content and, finally, end on a polemic note, to help motivate the methodological, practical and theoretical approaches found in the chapters below.

five new works

As stated, this thesis supports a portfolio of composition work. Musically, I have been primarily studying interactions between harmony, stochastic impulses and noisy texture. Harmony, used broadly here to describe pitch relationships, is typically practiced as an emergent feature of my work. While harmony is a core material throughout the portfolio, it is usually invoked on an indeterminate basis via the implementation of live electronics tools (*see also Di Scipio, 2003*) or the semi-controlled behaviour of improvising musicians (where I may direct the articulations, boundaries or contrasts of pitch, but would be unlikely to proffer any specific notes or intervals). The stochastic impulses and noisy textural materials were usually more pre-specified. Throughout each piece, I tended to have a more-or-less coherent understanding about the types of things that I wanted to hear, controlled via the implementation of familiar synthesis programmes (gutter synthesis, concatenation, FFT, etc), or by directing human players towards particular types of sound (timbres, preparations, envelopes, textures, etc). This more aggressive pre-determination of timbral sound material (as compared to my lackadaisical approach to harmony) comes from my practice as a computer musician: I am much more comfortable talking about music in terms of spectrum, electroacoustic transformation and live electronics technology, rather than contemporary or functional harmonic convention.

My portfolio is comprised of five primary musical works and each of the five following chapters is hinged around a specific work. While more detail is provided below, [Chapter 01](#) focuses on a semi-improvised concert work for solo guitar; [Chapter 02](#) features a concert work for ensemble and live electronics; [Chapter 03](#) is an audiovisual work for ensemble and electronics that was livestreamed as a video in concert; [Chapter 04](#) is a fixed media work of electroacoustic music; [Chapter 05](#) is an EP of pieces for ensemble and live electronics. This portfolio is provided alongside this thesis (submitted to PURE - the University of Edinburgh submissions system - and also to [Google Drive](#). Please email me if you are unable to access the Drive link) and the reader is directed to audio or video recordings of the work where necessary. When works were performed in concert, i.e. the pieces associated with Chapters 01 and 02, I have included documentation of the concert. The livestreamed piece featured in Chapter 03 is documented by video file. The fixed media material featured in Chapters 04 and 05 is provided as audio. In total, my portfolio of composition lasts around one hour in length. Before I move onto a more specific account of what this hour consists of, I want to quickly explain some of the theoretical and conceptual underpinnings of this study, alongside the primary argument of this thesis as a whole (music *and* text).

core argument

A core conceptual claim of this research is that my music practice exists as a complex set of abstract musical behaviours: the sum of all things that I do in order to compose music. This general framework encapsulates all musical activity carried out on a 'lower level', i.e. things done to ensure the production of sound in the context of a specific piece of music (playing instruments, recording, writing scores, producing code, etc). It is often easy to locate instances of redundancy between these lower level musical behaviours: things that are not only enacted in the context of a single piece, but are carried out consistently across my practice as a whole. I find it helpful to describe this set of general musical behaviours as a type of music system in itself: a high-level operational structure that both contextualises and overdetermines all lower level musical activity. However, and this is where my primary research problem starts to arise, I do not have a tangible interface for using this high level 'global' system. I was made hazily aware of its existence by the activities carried out on lower levels, situated around their own 'local' music system framework (i.e. each of the five works of my portfolio), and it is only by mapping between lower level system behaviours can I start to illuminate a higher order structure.

Without wanting to fixate the conceptual for too long, this mapping between high and low level depictions of music sets out a core theme of my research. On one hand, we have the 'high-level', 'global' and 'practice orientated' system. On the other, we have the 'local', 'low-level' and 'piece orientated' system. Analytically framing any differences between these systems is a process of navigating multiple perspectives. Each lower level instance of music helps populate the higher level system with new behavioural affordance, while the higher level system context encapsulates the behaviour of its lower level constituents. Both systems are depicting the same fundamental thing - my music practice - according to differing levels of analytical detail: the lower level activities are situated around their own specific work, therefore channelling a much narrower range of detail than my systemic explanation of my practice as a whole. This multiplicity of potential framing presents us with an existential and material problem. If music systems can be framed in so many different ways, what is it that these things are actually made of? Moreover, for the sake of music practice (and not theoretical analysis), which framings are worth paying attention to as I compose? With such a vast range of potential components, how should they be fitted together?

research problem

As eloquently stated by Georgina Born (*see above*), music is a complex assemblage of different mediations: "sound, score, discourse, site, performance, social relations, technological media" (Born, 2017, p. 44), etc. The specific auditory form of any music results from these complex situated interactions between a diffuse assortment of things. From this perspective, the perceived musical quality of a concert violin work

would result from the text of the score, the makeup of the instrument, the degree of musical training (which itself could be a marker of race or class), the acoustics of the venue, the historical context of the work, the tameness of the audience, the brightness of the lighting, etc. This perspective ushers in an enormous level of analytical detail into the problem of understanding why music forms as it does. As a composer, what parts of this assemblage should I attempt to control? As a computer musician, it is easy to default to technical assumptions of what to focus on. Such an assumption could frame sound as the outcome of *technological* process: the task of compositional practice solved by designing and working with code, FX and loudspeakers. While this seems to be a fruitful depiction of what computer music practice is, such framings can be dangerously narrow-minded.

According to Simon Waters (Waters, 2007, pp. 01–02) “those whom compose or perform, particularly in highly technologised environments, are wont to celebrate the technological, and to be reductive about (or at least less attentive to) the nature of music as an activity (as practice) – tending to consider the acoustic fact at the expense of social and cultural context”. We can find echoes of this claim throughout electronic and new music studies, alongside multiple approaches to bring these elided factors back into the frame (Born, 2021; Green, 2008, 2013, 2014; Hayes & Marquez-Borbon, 2020; Landy, 2021; Walker, 2021a; Waters, 2007). In and around this discourse, there is a shared assumption that music systems cannot be simply described according to their technicity. As such, the performance ecosystem describes musical form as resulting from interactions between three primary things: people, technology and performance space. While not as detailed as Born’s assemblage model of music practice, the performance ecosystem reframes details that were elided from the picture in my purely technological depiction of computer music practice.

In the prior two paragraphs, we have described music practice according to three levels of analytical detail. Born’s musical assemblage provides a totalising perspective on how music is formed by intense array of interlocking material factors, that combine to mediate the production and perception of any musical experience. My purely technological stance identified computer music as something that unproblematically occurs from siloed technical process: the outcome of time spent fiddling with computers. Waters’ performance ecosystem, spanning between these two poles, describes music as an emergent reaction between people, things and places. We can, of course, frame music in other ways. Indeed, there is a potentially infinite number of different framings as to what can constitute musical activity. Moreover, it is clear that different framings of music will be appropriate for different use cases: a harpist in a concert hall will think about music differently to a boxer entering a ring before a fight. This isn’t a matter of semantics, but of practicality: as someone who composes music by intentionally designing systems, it is important for me to know which details to include in their design. This, framed loosely and poetically here, is the primary claim of my research. In the following section, I more tightly define

how this exploratory depiction is supported by the main body content of this thesis.

structure of this thesis

chapter structure

Each chapter of this research follows the same fundamental structure. As already stated, each chapter is related to a specific component of the submitted portfolio of practice and structured around a primary research question. The chapter begins by briefly evaluating the relevant piece, before giving a short rundown of the relevant research question and the structure of the chapter. Following this, the first section of each chapter is used to further evaluate the chapter's work of music, with specific reference to the materials that are provided in the submission (i.e. the contents of the musical work are described). This work is then put into a wider artistic context that is correlated to the specific artistic or methodological approach to composition, or to the research question at hand. In the second section, the practical work is fully described as a 'music system'. The specific way that each music system is framed in text corresponded to the type of musical outcome that I was working on. In the third section of the chapter, the work is discussed according to the core 'abstraction' that the chapter is themed around. This abstraction is first evaluated as something that exists in the piece, then discussed in relation to contemporary music practice in general terms, before being evaluated according to its ability to generate a specific type of musical experience. This occurs in relation to a final analysis of the piece, based around thoughts that came up when I listened back while writing up this thesis. I conclude the chapter by recapping the primary aims and threading together a response to the research question, before mapping it more generally to the title question of this thesis.

chapters:

chapter 01: can I treat a human like a software patch?

This question: '*can I treat a human like a software patch?*' cements an abstract relationship between the way that I interact with human beings and the way that I control software. This work was composed as a way of giving myself a set of instructions that are similar to things that I would communicate to a software synthesis engine. I did this by identifying a core interface concept that I associate my practice as a computer musician: 'presets'. As a MaxMSP programmer, I typically define multiple presets of parameter information that can be stored to disk and recalled at will. This allows me to be able to save 'states' of sound that I like and reproduce them at any arbitrary time in future. Typically, in computer music approaches, I would deploy interactive means of moving between different states at will. To generate this behaviour without a computer, I specified a set of 'presets' that determine how I can interact with my guitar and specified a method for navigating through these states in semi-improvised performance.

chapter 02: how are clocks embedded into music systems?

By asking '*how are clocks embedded into music systems?*', I explore some abstract forms of temporality that are exploited in composition. To this end, I formed a connection between the timeframes of the Bitcoin blockchain (Nakamoto, 2008) and the structure of a fixed media piece of electronic music. To motivate this question, I refer to Michelle Bastian's loose definition of clock as "a device that signals change in order for its users to maintain an awareness of, and thus be able to coordinate themselves with, what is significant to them" (Bastian, 2012, p. 10). This concept is compared with two musical approaches to instantiating time: Erik Christensen's theories of listening (Christensen, 1996) and Curtis Roads seminal timescales of music (Roads, 2004). Music systems, as things that generate specific technologies or methods for the production or measurement of time, provide a basis for exploring the specific understandings of time that are embedded into my practice.

chapter 03: assimilation or dissimulation? A sociotechnological feedback study

'*assimilation or dissimulation?*' is a reference to the title of a piece that I composed with my friend and colleague Aggelos Mastrantonis. As this chapter will demonstrate, these two ideas provide a useful basis for exploring the complex relationship that existed between myself and Aggelos throughout composition. In broad terms, we identified this process as a form of socio-technological (i.e. communicated between humans and technology) feedback loop, where we passed material between each other and worked on it according to our own expertise (harmony and score production in Aggelos's case; live electronics and MaxMSP programming in mine). This task can be seen as an assimilation of two practices into one: the integration of heterogynous processes into an abstracted working form. Conversely, in order to understand each other while working on the piece, we had to communicate our working process in a way that the other party could easily understand. This necessarily meant we had to mask certain complexities: we dissimulated elements of our practice while we communicated with each other.

chapter 04: how are social relations embedded into music systems?

This chapter's question - '*how are social relations embedded into my composition work?*' - describes the complex social relationships that bear upon the musical behaviour of music systems. Specifically, I describe the composition of an audiovisual work composed with the PlusMinus ensemble (Plus-Minus, 2022). Throughout composition, we sent sounds to each other via email and recorded ourselves responding to these sounds in pre-established and loosely specified ways. I edited these exchanges into a short video. The musical form of the work emerged from the specificity of these social interactions, carried out through sound, email and video. I relate this piece to broader ideas regarding social aesthetics in contempo-

rary arts practice, specifically Nicolas Bourriaud's relational aesthetics (Bourriaud, 2008), Claire Bishop's polemics on the politics of participatory art (Bishop, 2004), and Georgina Born's theories on art and social mediation (Born, 2017).

chapter 05: can I treat a MaxMSP patch as a human?

Similar to Chapter 01, this chapter's title question - '*can I treat a MaxMSP patch as a human?*' - unpicks an abstract connection between machines and people. This work was carried out as part of the Institute for Electronic Music's Inter_Agency (IEM, n.d.) study into composition and artificial intelligence. My approach to this project was realised as a short series of experiments that eventually realised a short EP of fixed-media electronic music. The materials of this piece were developed across a series of solo explorations with machine agency, which led into a set of rehearsals with Manuel Alcaraz Clemente and Margarethe Maierhofer-Lischka of Graz's Schallfeld ensemble (Schallfeld Ensemble, 2021). This piece was never finished, due to the COVID-19 pandemic, so the submitted output of this project was moulded into an EP (made up of materials recorded from rehearsal with Maggie and Manu) rather than a concert work. This provided me with the opportunity to more deeply probe what I wanted from the musical combination of machines and people, providing a sonic basis to establish how I want people and machines to interact in live performance.

contribution

To explain how this track to more verifiable research outcomes, as a total structure (of music *and* text), this work variously provides contributions to live electronics composition, computer music studies, improvisation studies, musical cybernetics, contemporary art and artificial intelligence and musical creativity. In the following section, I take three approaches to articulating what my primary contribution is. First, the contribution is monolithically contextualised as something to benefit contemporary music/art studies and practice. Second, I discuss the specific contributions made during each chapter. Here, I am keen to stress where my research has already seen (/been peer-reviewed in) the cold light of day: in concert performances, publications and presentations at conferences/seminars, alongside future potential research outputs. Third, I evaluate the ‘non-musical’ fields of study that this thesis is adjacent to, to articulate the interdisciplinary benefits of this work and ultimately address what I want this research to do in future. This latter point, helpfully, lets me set out what I see as the most exciting contribution of my PhD research and the future research potential that I see in this idea.

contributions to contemporary music/arts practice

As a novel contribution to contemporary music research, my PhD research serves four primary functions. First, we can identify new music and technique. My portfolio encapsulates a range of different approaches to working with sound, including semi-directed improvisation, fixed-media acousmatic composition, score works for ensemble and live electronics, spectralism (thanks for Aggelos Mastrantonis’s contributions to *Assimilation / Dissimilation*, see Chapter 03) and music for automated systems. The specific implementations of these practices, and the ways they correspond to each other, provides a novel account of machine-human composition strategies that are relevant to practitioners who are interested in similar creative practice. Underscoring the sonic outcomes of this process is a coherent set of new musical techniques. While the specifics of new technique will be recounted on a case-by-case basis throughout this thesis, these strategies largely coalesce around methods for directing people and technology to make sound on a semi-autonomous basis, and for allowing musical outcomes to emerge from complex and interactive performance contexts. While the approach that I took to carrying out these tasks is idiosyncratically geared around my own taste and practice, they will be of interest to practitioners and researchers who similarly fixate on people and computers.

Second, this work provides a practical solution for mapping between the distinct analytical framings music or art. As stated above, different framings are appropriate for different ways of practice: the extent of detail at hand will impact the controllability of the system. My method of generating ‘abstractions’ provides a meaningful way of framing this design problem. Identifying positive details that remain consistent throughout different framings provides a practical way of focusing on core

structural details. The specific abstractions that are determined from this process are likely correlated to the working sensibility of the designer at hand: values governing what they may wish to see enacted by their systems. This provides a lucrative basis for projecting such things outward and instilling them into new systems by: devising structural and procedural approaches that are supportive of desired material statuses (see Chapter 01); thinking through the ways in which systems change material through time (see Chapter 02); identifying specific channels through which information is communicated throughout the system and exploiting this to reinforce positive behaviour (see Chapter 03); communicating aesthetic desires to other people, while mediating collaboration, so that all parties understand and support the aims of the work (see Chapter 04); or encoding technologies that to autonomously enact the aesthetics sensibility of their system designer (see Chapter 05).

Third, this approach to identifying ‘abstractions’ that exist across multiple material framings of the work (i.e. things that can be technological *and* social - digital *and* analogue - symbolic *and* literal) affords a useful basis for more fulsomely recognising the specific set of mediations that give rise to musical experience. In the context of electronic music, this combinatorial approach helps to avoid the over-fixations on technology that are widely documented (Born, 2021; Green, 2008, 2013, 2014; Hayes & Marquez-Borbon, 2020; Landy, 2021; Walker, 2021a; Waters, 2007). This idea can not only be applied as a post-factual analysis of existing works, as a way of determining how their core constructs operate through different frames, but can also be embedded into the technical design of new creative systems: works of art or music emerging from this complex relationship between specific system behaviours and general material affordances. My five portfolio works were generated by identifying these abstract behaviours, variously spanning: between myself, my instrument and my computer (see Chapter 01); between different timescales of musical and non-musical experience (see Chapter 02); between feedback loops as technological and social patterns of behaviour (see Chapter 03); between different ways of interacting with musicians socially (see Chapter 04); and between ways of communicating desirable aesthetic outcomes to both humans and machines (see Chapter 05).

Fourth, I document a clear theoretical relationship between the design of music systems and the perception of music. The process through which abstractions are generated from music system behaviours is correlated to the means in which musical structures are interpreted by human perception (see Christensen, 1996). Our ability to listen to music is predicated on a complex relationship between perceived and general qualities of sound (i.e. loudness, timbre, pitch, spatial location, etc) and our motivation to combine these features into more specific perceptual structures by measuring the way that they change through time (i.e. metrical changes in loudness becoming a pulse or rhythm; pitch changes over the duration of a piece clumping together into a singular harmonic overlay; small bursts of sound at intervals of less than 10hz (Roads, 2004) fusing into the perception of continuous sound events).

This ability to make useful generalisations about how sound is formed by general components and specific mediations is embedded into the very fabric of our musical listening. Perhaps these means for producing structure are not exclusively found within our bodies and minds. I polemically suggest that these structural detection mechanisms are embedded into everything that we do as we make music: they exist similarly within musical listening *and* music system design; what happens when we exploit these correlations between making sound and perceiving music? While these ideas are framed throughout my main body text, I unpack this idea more thoroughly in my Conclusion.

contributions of each chapter

Moving towards a more specific account of research contributions, *Chapter 01* explores a novel way of structuring a semi-improvised work of music by focusing on compositional approaches more common to electronic music. While we can identify existing research into the cybernetics of improvised performance (Pickles, 2016), I have yet to see someone take this specific approach to improvisation, especially as a means of producing a deeper and more embodied exploration of electronic music aesthetics. The piece that this chapter discusses was publicly performed at Edinburgh Art Festival in 2019.

Chapter 02 provides a musical exploration of a technology and cryptography/cryptocurrency, and a critically expanded practice of temporality in music system design. This latter point is achieved via a synthesis of philosopher Michelle Bastian's (Bastian, 2012) radical philosophy on time with existing approaches to identifying the temporality of music (Christensen, 1996; Roads, 2004), both as a perceptual and practical phenomenon.

In *Chapter 03*, while we can identify a rich history of feedback in technological music systems (Sanfilippo & Valle, 2013; Waters, 2007) - and variously identify the feedback loops that occur between audiences and musicians (Bailey, 1993; MacDonald & Wilson, 2020), this is the first written study that I have seen that explores the idea of producing feedback as a productive connective between two compositional practices. Moreover, Aggelos Mastrantonis, my collaborator, has successfully passed his viva with this work featured as part of his portfolio, with feedback received from his examiners folded into the latest version of the score and code. As such a core theme of computer music, improvised music, audible ecosystems and cybernetics, not to mention my own music, this strand of research into 'feedback' will be a consistent feature of any publications and practice that I carry out in future.

Chapter 04 synthesises theories from electronic music and social aesthetic, exemplified by a type of music practice that was general especially to study the sound aesthetics of the COVID-19 pandemic. This theoretical component of this chapter (i.e. the synthesis between relational aesthetics and live electronics discourse) will be submitted in an upcoming issue of the Contemporary Music Review that discusses re-

relationships between contemporary art and music as two separate discourses, guest edited by Kieran Curran. As fodder for future presentations, the relational aesthetics of computer music as are largely unexplored. This is despite the fact that new models of understanding social relationships have continually emerged from complex and technologised music, specifically in cases where human beings are invited to musically interact with computers who can perform rudimentary social musical functions (i.e. improvising alongside musicians (a la [Gioti, 2018](#); [Lewis, 1987](#); [Parker, 2013](#))).

Chapter 05 interrogates the ethics of artificial intelligence as an aesthetic cultural phenomenon (see [Born, 2021](#)). The practical work of this chapter was generated in an artist residency with IEM's Inter_Agency project ([IEM, n.d.](#)), funded by the European Humanities Research Council and the Austrian Science fund. Moreover, the ideas covered in this chapter have been presented in conference three times ([Walker, 2019, 2021a, 2021b](#)) (alongside an accepted and forthcoming performance at the International Computer Music Conference this year (2022), and, fingers crossed, a presentation and performance at the next ACMC), and presented at a seminar at IEM in Graz ([Walker, 2020](#)). Ideas and practical tools from this chapter were workshopped with FluCoMa ([FluCoMa, n.d.](#)), another EHRC funded project, who provided technical and conceptual support.

interdisciplinary contributions

For the majority of time spent completing this thesis, I have co-edited Edinburgh College of Art's *Airea* journal in arts practice and interdisciplinarity ([Airea, n.d.](#); [Lycouris et al., 2021, 2020](#); [Talianni et al., 2018](#)). Throughout this process, I have had the opportunity to reflect on my own relationship to this idea: that multiple disciplines can temporarily combine into one as a way of strengthening the capabilities of the individual components (see [Born and Barry, 2015](#)). While it is clear that my study is interdisciplinary, due to the different fields variously deployed (music practice, cybernetics, contemporary art aesthetics, artificial intelligence, etc), I have had no interest in talking about interdisciplinarity. It simply wasn't something that I was thinking about while composing and it wasn't worth building into the research later. However, the notion of interdisciplinarity does serve some small function here, as this project has corresponded with research problems that lie outside of 'music'.

First, as research into cybernetics, this project proffers a useful basis for exploring how systems are produced on a personal and contingent basis. This is a striking contrast to a great deal of literature on the subject, which often concerns itself with much broader ramifications of systems behaviour, i.e. warfare, business, nationality, human cognition etc ([Beer, 1995](#); [Mead, 1968](#); [Pickering, 2011](#); [Wiener, 2007](#)). My smaller-scale dive into systems development provides some useful accounts of how systems are produced by individuals for very specific functions. The actual nature of the systems that I develop, as things that are orientated around the production of aesthetic experience, are likely to be of interest to anybody else who is practic-

ing or researching the connection between art and systems. Second, still on cybernetics, my conceptual approach to organising different framings of systems again provides a useful philosophical standpoint on how different systems, when roughly orientated around the same subject, can network and communicate with each other: abstraction existing as a form of sharing information throughout multiple systems.

Finally, the most exciting contribution of this research (and the one that I am most likely to seriously engage with in future) pertains to artificial intelligence. To this end, the core research question that I will take moving forward is: *if we accept the presupposition that machine can make musical decisions, how are we to ensure that we like the decisions that they make?* I use this to unpack the notion of embedding an artistic or musical sensibility into a machine. As computers continue to develop in sophistication here, such problems will be presented with less barriers. To ascertain what it is that people actually want from AI, I believe the question is worth asking before this point. Throughout this doctoral project, I have been fixated on the idea that it is possible to use music systems as a way of determining and propagating musical work ethics: systems built to enact the positive things that we want to hear in our music. The notion that technological systems can be imbued with human sensibilities (or can at least act as if they are) is relevant from both musical and more broadly cultural standpoints on the future of AI: *if we can accept that AI tools can make decisions that impact society at large, how can we ensure that we benefit positively from the choices they make?* These ideas are more firmly explored in Chapter 05.

composing abstractions?

Throughout this thesis, I describe a number of music systems by using a variety of different analytical frames. In doing so, I identify persistent features in my music system design. This is a matter of locating redundant information: things that consistently appear throughout multiple local framings. I call these things ‘abstractions’, or occasionally ‘musically generative abstractions’. They are: a) ‘abstract’, in that they exist at a higher analytical order than any lower-level system context, and b) ‘musically generative’, because I can use these things to create new music. My thesis title’s research question - ‘Composing Abstractions?’ [a nod to Agostino Di Scipio’s -Di Scipio (2003) notion of composing interactions between system components) - underlines the importance of this concept in relation to this thesis. I wish to end this chapter with a slightly more audacious claim (as I am free to do in poetic terms before I expand more rigorously throughout this thesis). There is a strange, resourceful and alchemical power in this practice of organising musical abstractions. Moreover, new works of music can be formed by evaluating the ways in which these abstractions coalesce and sustain themselves. Identifying these things, and carefully sorting them, allows compositional systems to emerge from, rather than elide, the diffuseness of music as an aggregate of different forces. Self-reflexively, this is a task of learning more about my musical practice, by: implementing music systems, de-

scribing them with a number of framings and seeing which parts consistently appear as positive elements. As the 'positivity' of these elements is judged by my own taste and working sensibility, the abstractions that crop up will be correlated to personal values that I hold about music: things that I wish to see repeated in future. There is, of course, a negative framing of this problem: what happens when my music does things that I dislike? These 'messier' facets of my research - and their bearing on my methodology - are discussed in the following chapter.

To end this introduction, I want to be very frank about what I think of the work. This seems fair, given my self-centred (sorry, 'practice-led') approach to doing research: this work wouldn't exist without my ego. In understanding this self-feedback process, I am channelling Cornelius Cardew's Marxist-Leninist (1974) stance on critique: criticism of this work should be carried out to make it stronger. To this end, I hope that you are able to parse through the messier components (clunky performance; mixes/masters that would have benefitted from longer in the studio; theories written four years ago and transplanted onto newer practice, or vice versa; etc). Maybe you wouldn't have noticed these more formative elements without my signposting them here, but I want to be explicit about where this work could mature (as will be seen below, this notion is of clear methodological importance). The bits of the work that I like best - and would most like to reinforce - are moments in which I articulate complex musical ideas (sonically or otherwise) in a perceptually relatable fashion. Musically speaking, every work in this portfolio documents compositional techniques that I had never seriously undertaken before. While this led to some wonderful creative moments that would not have occurred otherwise, I can occasionally hear clumsiness, contextual insensitivity and a lack of formal coherence. Moreover, on a theoretical basis, my most interesting ideas usually stem from a part of myself that I don't have conscious access to. These bits of the psyche (as well-documented by Jung, 1995; Jung & Jung, 2009) can communicate in an obtuse style, which should be, ideally, rendered down into more easily relatable language. While I did take care throughout this process, it is an ongoing task that will persist throughout my career: there are a lot of ideas in this text that will make more sense to me with further practice. In short, I love this work - even the mess - and I have a lot of research to unpack from it (and similar studies) in future.

methodology: mess, spirals and iteration in practice-led research

While participating in the viva examination of this research, I was warned off instances where I wrote with a tone of self-deprecation, or perhaps an off-putting degree of sincerity regarding the shortcomings of my work. This was, by definition, expert guidance on continuing to construct the thesis materials, as I worked through the set of minor corrections that were generated by the reviewers' appraisal of my research (and this positive stance on self-presentation is channelled presently, as I use this sentence to quite vainly indicate my only getting minor corrections). However, while I cannot entirely remember how I 'defended' myself against this accurate claim, I am fairly certain that I would have drawn back to my primary theme of analytical framing. Everything that I do as a researcher produces mess. This mess takes two forms: things that are unnecessarily complex and difficult to handle, to the detriment of any tidier and more easily communicable research outcomes that are hiding beneath them, and experiences that I do not want to repeat, and would wish to sanitise from my future. These two framings of mess - as synchronic negative particles that devilishly occlude the warmer and more comforting elements of practice, and as diachronic negative moments that seek to disintegrate themselves from my experience of time moving forward - are highly relevant to this chapter in particular. As a core component of my methodology, I want to draw attention to role that mess - disorganisation, chaos, incoherence, failure - played in this doctoral study. This isn't to frame the research in a negative light, but to explain why things formed as they did, and to encourage a frankness in representation in my part as I explain what it is that I do as a researcher.

mess

I begin with an assessment of the two forms of mess encountered above. First, the geometric type of mess – things that can be observed getting in the way of other things – is typically generated simply by being conscious of form. Without an ability to discriminate between a desktop and the clutter that stops you from wanting to sit at it, both things bleed into one and the desk loses practical value. The perceptual separation of ‘desk’ from ‘mess’ is a means of prioritising a sense of operationality in the workspace, thus demonstrating a small functional change that could be made upon reality in order for some work to happen. Commonly, the task of enacting this change, thereby modifying reality to better fit the things that you want to do with it, leads to the propagation of yet more mess. Items that are useful in one working context – coffee cups, unintelligibly named .wav files, trombones – can reduce the ease of operating in another. To frame this problem in artistic terms, the distinction between desirable and undesirable aesthetic elements is often a case of experience and moderation: listening to recordings of myself playing badly usually shows me how I would prefer to perform, but elements that I may seek to diminish from my playing (accidents, lack of congruence with co-performers, pastiche), can typically be dampened into more useful things (spontaneity, counterpoint, contextual sensibility). A simple metaphor is signal-to-noise - the market popularity of analogue emulation plugins (digital sound processors that deliberately enact the non-linear distortions imposed by analogue recording media) is clearly indicative of a taste for organised grit: a fabricated sense that something is going wrong in the world. If we wanted perfection we would listen to sine waves. However, if noisiness is sufficiently high, it is impossible to distinguish the signal from any other, and the world collapses into an oppressive homogeneity, where sound can only penetrate without meaning (this can be aesthetic in itself – I like the solipsism that can arise at good noise shows: communication with other people is impossible, and the music can be so formally consistent – i.e. loud – that it becomes easy to grasp as something entirely sensorial, *see Voegelin (2010)*).

Second, the temporal type of mess – moments that are encountered so that they can never happen again – are similarly instructive. The process of producing this research was chaotic and messy, and it was often very difficult to know what it was that I was doing until I had done it. If I was to start a PhD now, there is a lot that I would do differently. Moreover, without wanting to unpack any semantic baggage here, I consider a lot of my music practice as experimental. Experiments can fail. I have composed pieces of music throughout the process of working on the PhD that I chose to document here (i.e. I framed them out of this narrative account of my research), either because the prototypical materials never formed into something with demonstrable substance, or a potential collaboration was stilted by extraneous factors. Alternatively, in a very small number of cases, I simply didn’t like how it made me feel. While only tacitly occupying the text and portfolio of the research, these ‘failures’ – messy encounters with my inability to produce on target - often re-

vealed the most. This latter point maps to a useful polemic on practice-led research: that the most penetrating forms of knowledge are impossible to communicate via a doctoral thesis. This isn't a trite 'school of hard knocks' diminishing of cloistered academies, or a refutation that expert scientific research is needed to mitigate literal catastrophe, but an observation that humans are very bad at knowing what we want. As conscious beings, we navigate the world according to the most historically lucrative frames of reference that our egos can provide – our base interface for navigating consciousness Gaffa taped together by scared and selfish children. The positive framing of this outcome is that it is remarkably easy to identify sources of comfort in the world and generate things that we want to move towards. The downside of this defence mechanism is rigidity of thinking: the idea of a guaranteed and beneficial endpoint. If this point is reached, the navigational structure is reified, yet only temporarily satiated (having immediately forgotten its most recent fix, it will vampirically bound towards a fresher source of dopamine). If failure occurs, it fractures or is forced into reassessment. While my latter take is clearly polemical and written without the psychological training for it to be read as anything other than metaphor, this process of alignment and reassessment is a core methodological focus.

My take on 'mess', as either something to be removed, something to learn from, or as a fun little spice for reality, is similarly rhetorical: other framings will clearly exist. John Law takes a more holistic perspective, arguing that mess is anything framed out of the picture when people want to see something. From the perspective of scientific research, this harks to a, laudable, desire to understand the world with certainty – reality operates a singular level and scientific method is applied to uncover its technical attributes. In such a purview, methods are uncritically applied to determine the state of the world as it currently is, counter to perspectives that would see their application as the production of new reality. Law argues that this conventional methodological focus is extremely good for uncovering some kinds of data – case studies briefly given include the relationship between smoking and lung cancer, and the impacts of poverty on health and social wellbeing - but claims that the hegemony of this methodological cleanliness imposes data collection norms to subjects that do not need them, i.e. “the study of the ephemeral, the indefinite and the irregular” (Law, 2004, p. 4). Law claims that the conventional stance can be wrapped up in the following statement: “If you want to understand reality properly then you need to follow the methodological rules. Reality imposes those rules on us. If we fail to follow them then we will end up with substandard knowledge, knowledge that is distorted or does not represent what it purportedly describes” (Law, 2004, p. 5). This tracks to Law's assertion that there is a widely accepted Western (or 'Euro-American' in Law's account) view that messy research methods lead to messy results: a distortion of reality. If we start to do away with this normative assessment on the state of research, “(t)he picture of method starts to shift. The argument is no longer that methods *discover* and depict realities. Instead, it is that they participate in the *enactment* of those realities. It is also that method is not just a more or less com-

plicated set of procedures or rules, but rather a bundled hinterland. This stretches through skills, instruments and statements (in-here enactments of previous methods) through the out-there realities so described, into a ramifying and indefinite set of relations, places and assumptions that disappear from view” (Law, 2004, p. 5). This acceptance of complexity and multiplicity invites messiness into the picture in order to more acutely produce research around the world(s) at play: “If the world is complex and messy, then at least some of the time we’re going to have to give up on simplicities” (O2). While not an outright attack on the ontologically ‘purest’ of contemporary Euro-American scientific methods, which he is extremely careful to document the value of, Law favours a process of method assemblage:

“Method assemblage is the process of enacting or crafting bundles of ramifying relations that condense presence and (therefore also) generate absence by shaping, mediating and separating these. Often it is about manifesting realities out-there and depictions of those realities in-here. It is also about enacting Othernesses. If we think this way then reality, realities, take on a different significance. No longer independent, prior, definite and singular as they are usually imagined in Euro-American practice, they become, instead, interactive, remade, indefinite and multiple. But if this is right then it suggests we need ways of exploring the enactment of and the interactions between different realities. There is a need for tools that allow us to enact and depict the shape shifting implied in the interactions and interferences between different realities. There is need for assemblages that mediate and produce entities that cannot be refracted into words. There is need for procedures which re-entangle the social and the technical. There is need for the coherences (or the noncoherences) of allegory” (Law, 2004, p. 122)

spirals

Law's generative (i.e. making new things a reality) as opposed to deductive (i.e. defining what reality already is) approach to methodology resonates with action research – a school of thought established by sociologist Kurt Lewin in 1946 (Lewin, 1946). Action research encompasses “research methodologies which pursue action (or change) and research (or understanding) at the same time”. This process often takes a “cyclic or spiral process which alternates between action and critical reflection, and in the later cycles, continuously refining methods, data and interpretation in the light of the understanding developed in the earlier cycles. It is thus an emergent process which takes shape as understanding increases; it is an iterative process which converges towards a better understanding of what happens” (Dick, 1996). The form of the research consolidates into knowledge as the research follows this iterative path, oscillating between these continual processes of action and reflection. Chiming with Law's prior distinction between ‘messy’ and conventional methods, action research can be posited against normative conventions: “The normal position of the researcher is detached, scientific, standing outside events and diligently recording them. A number of methods may be used – questionnaire, focus group, interviews, observation, etc. – but it is generally the researcher who controls data gathering for purposes that affect their research rather than the participants’ agenda. In other words, the subjects are passive in research terms: they may either be unaware of being “watched” or unconcerned about the data used from their interview or survey” (Emerald Publishing, n.d.). The production of knowledge occurs throughout encounters relationship between researcher, participant and project: with the specifications, methods and results of the study emerging as a reflexive outcome of this process.

Certain correspondences between Law's ideas, action research and this project are hopefully apparent, especially when weighed against the primary research problem at hand: the diffuseness of music as an assemblage of interrelated factors, and methods that can be taken to frame out this complexity and generate musical outcomes. Moreover, in a satisfyingly emergent fashion, it is relevant to note that both Law's ‘messiness’ and action research were introduced to me *after* I had completed this research, despite the fact that multiple commonalities exist. First, tracking back to Law, my means of identifying abstractions that exist between multiple different instances of music systems - each of which designed with its own sense of aesthetics, technicality and performability - has a key similarity with his concept of ‘resonance’. It would be disingenuous of me to drive this point too far, as it was never explicitly a part of my research design until after my viva, but we can briefly entertain the idea that constructing different music systems is a process of creating different realities. He explains this process in pleasingly sonic terms:

“(M)ethod assemblage can be understood as resonance. This is because it works by detecting and creating periodicities in the world. The picture of reality that lies behind this removes us from the most common version of Euro-American metaphysics – the sense that the real is relatively stable, determinate, and therefore knowable and predictable. The alternative metaphysics assumes out-there-ness to be overwhelming, excessive, energetic, a set of undecided potentialities, and an ultimately undecidable flux. Sometimes, however, and in method assemblage, out-there-ness crystallises into particular forms or (a different metaphor) collapses for a moment into decidability. If method assemblage can be seen as resonance then this is because it detects all the periodicities, patterns or waveforms in the flux, but attends to, amplifies, and retransmits only a few whilst silencing the others (Law, 2004, p. 144)

At a high level of abstraction, the task of framing a singular reality through music (i.e. an event that multiple people could classify as a single concert performance) is an enactment of this resonance. Performing music to an audience is a method assemblage for ensuring a multiplicitous production of musical experience. While any one member of the audience will construct this performed reality in a different way to any other (physically through their position in the performance space, the shape of their ears and the relationship between body size and sound absorption; psychically through taste, cultural conditioning and their expectations of the music; or physiologically through energy, hunger levels and degree of inebriation), there is clear resonance throughout these framings: we can wrap them all up (or crystallise them) into the notion of a single concert performance. While true of any music practice, this is especially pertinent to the aims of my investigation. In finding commonalities between multiple different instances of my music systems, I am deliberately establishing resonances between the types of music that I create: a method assemblage made from method assemblages. Although I never would have used this terminology while conducting the research, there is enough crossover here for Law’s ideas to contextualise my own.

At a lower level, this notion of periodicity is also carried through action research, where projects undulate between action and reflection. This continual shifting between doing things and critiquing them, without necessarily knowing where this force is leading to, has emerged consistently throughout this research project. This balance echoes a claim by musicologist Nick Cook (Cook, 2018), that the composition of music necessitates a procedural balancing of rational and intuitive processes: composers specifying rational frameworks for their output which are then fleshed on an intuitive and aesthetic basis. I initially described this shifting between making things, evaluating them and then re-making them as an ‘iterative process’ (see below), but when challenged on my methodology in my viva used the metaphor of a ‘spiral’: something that is continuously cycling until you cannot see it looping any

more (again, I was unaware of the use of the term ‘spiral’ in action research - this is another happy resonance). This isn’t to suggest that my workflow was deterministic or always singularly directional, just that the acts of composition, coding, writing, editing, etc were imbricated in a wider pattern of doing things, testing them and then doing them again. Similar to action research, this process was not something that I enforced, top-down, upon musical ideas until they took shape into performance, but was a situated engagement with the aesthetic, social and organisational worlds that my research was entangled in. This is not to rid myself of responsibility or interrogate my authorship, but to illuminate the vast degree of mediations that go into any musical activity, and the way in which I am framing these ‘external’ presences in my research.

iteration

Prior to the idea of my research being a spiral, I would have used the term *iterative*. It is worth briefly recasting my methodology in such terms here, as it adds a sharper degree of methodological technicity to the looser patterns explained above. In general terms, an iterative methodology is repeated over three stages. First, something is made. Second, the thing that was made is evaluated, typically by the people who made it (or people who have an interest in its improvement). Third, the thing is made again, to account for any changes that were suggested by evaluation. Ideally, this recursive sequence allows for continual and incremental improvement, as the work goes through this process of production, evaluation and reproduction. Eventually (usually when a deadline or exhaustion hits), the thing stands alone, and exists as something that is divorced from this cycling gestational process. Iteration can be identified across all major developmental stages of this doctoral project: through composition, coding, writing, presenting my ideas at conferences, meeting with supervisors, etc. Musical ideas were rehearsed/workshopped before performance; technical approaches developed for a single project were carried over to other later works; chapters written in chaotic and stream-of-consciousness (or over-stimulated and manic) styles were tranquilised and chopped up into this current document; ideas were tested out on live audiences (consensually) before becoming part of this thesis - at conferences, workshops and the pub; etc.

To put this idea in a wider context, we can identify similar patterns in the technology industry. Software engineers employ iterative methods as a way of allowing the process of incrementally developing code, “feedback from one iteration is used to improve the execution of later iterations” (Jalote, 2005, p. 37). Early examples are generally prototypes or proof-of-concepts, with subsequent iterations ideally getting closer to a finished product. Iterative approaches to allow the needs of the product to develop alongside the technical implementation of ideas (ibid); the scope of what the software ‘should do shifts according to what the software has already done. Staying on this technical theme, we can find this approach in new music technology. According to Daniel Mayer, “it’s typical that algorithms for synthesis come into being in feedback loops, where aesthetic judgments are influencing further refinements” Pluta (2021). This resonates with Michael Edward’s critique of randomisation in musical algorithm design: “(g)iven the code->generate->evaluate development loop that much algorithmic composition involves, randomness can create problems in that it is by definition non-repeatable” (Edwards, 2019). While Mayer’s take on iteration is here expressed in more general terms than my own, and Edward’s reconfigures the pattern to place evaluation at the end of a chain, with ‘production’ exploded to two acts of ‘code’ and ‘generate’, and ‘reproduction’ implied by ‘loop’, each example maps between iteration in coding and music practice.

To look outside of software development, we can locate this (to steal Edward's grammatical formatting) 'production->evaluation->reproduction' cycle in a humanities context. First, it supports a simplification of Hegelian dialectics (see [Maybee, 2020](#)), where logical argumentation argument spans from thesis->antithesis->synthesis. In this pattern, something that is known is stated. This initial positive 'thesis' is then negated via a valid but opposing 'antithesis'. A unification of these two claims is then achieved via a 'synthesis', able to support the assertions made by both prior claims. Within my 'produce->evaluate->reproduce' development cycle, the 'thing' that I make is the combination of my thesis and my portfolio: a material that exists as a positive thing in the world. The antithesis is achieved via a critique of this object: 'yes, the thing may exist, but it is strange, and I don't like it for the following reasons'. Synthesis is achieved via reconstructions that enfold this critique. This is not to state that all critique is valid and must be accounted for, but to map out a general iterative framework that is be consistently applied through my research. This thesis-antithesis-synthesis cycle can be elsewhere located in music and sonic arts practice: Gioti et al ([Gouadarzi & Gioti, 2016](#)) outline their standpoint on participatory sound art, stating that the responses (antitheses) that audiences give regarding participatory sonic artworks (theses) can lead to improvements to how the work is reconstituted in future; while Bailey ([Bailey, 1993](#)) observes ways in which audience's (antithetical) responses to (thetical) improvised performance can lead players to (synthesizationally) modify their work in real-time. Clearly, this process of enacting something, weighing up the results and then modifying the initial action is a common strategy to the technical and expressive components of music practice.

oppositions

To illuminate another potential messiness, two core ideas of my thesis are discrete and step based, as the three-staged processes explained above, and continuously variable and spiralling off wherever they need to. Is there inherently a tension between these two ways of working? As should be an uncontroversial claim at this point, we can identify both modes as two different framings of the same methodology. An obvious parallel is the difference between continuously variable analogue waveforms and the discrete choppiness of a digital sound. Functionally, we can discuss each one as 'sound', even as the same sound, but we can very different affordances and limitations regardless of the storage medium at hand. There is perhaps a sense of linearity imposed by this specific method, in that recording would allocate immediate primacy to the analogue waveform generated by a microphone, which is further hierarchised by the fact that no digital sound can transmit acoustically without taking analogue form as an intermediary. However, in my own ontology – which, again, should be becoming increasingly easy to predict – sound is 'sound'. The abstraction is the focus of my interest and, quite literally, the focus of my attention as I work on sound by listening. The transduction process of hearing myself

Speak into a microphone through a computer (body -> acoustics -> analogue -> digital -> analogue -> acoustics -> body) terminates at my consciousness; the technical sub-permutations of this fact are only useful insofar as they can be instrumentalised within the context of specific control mechanisms (as things that I can reasonably call music systems). The parallels to my research here are similarly instrumental: it is simply helpful for me to frame my research in different ways at different times. Channelling John Law, the specific realities that these methods create will vary according to what I want to do with them. The resonances that occur between these points converge into the singular abstract form that I can enact as my methodology. From this framing, my methodology formed itself by using my methodology.

music systems as practice-led research

To put this into yet more specific terms, as a practice-based study into music systems, this research project holds two core assumptions. My first assumption is that the musical outcomes of these systems can be used to generate research questions, test hypotheses, substantiate or evidence knowledge claims, or communicate findings to an audience. This is a common feature of the way that artistic outputs are mobilised within practice-led research projects (Smith, 2009). Moreover, to look towards the specificity of performing using on music systems, a second interrelated assumption is that specific framings of system behaviours can be used to produce general knowledge claims about how systems operate on a broader scale. This resonates with science historian Andrew Pickering's (2011) claim that system dynamics can be performatively framed a way of instructing audiences about how systems behave more generally. This connects nicely to Christopher Small's (1998) assertion that musical performance affords humans the ability to ritualistically embody the type of world that they wish to inhabit: local and perceptually rendered musical behaviours tracking to global assertions about how the world behaves and how they inhabit it. Both of these ideas are closely related to the specific way in which I make claims about music practice by designing and documenting music systems.

This broad polemical basis trickles down to general ways in which I frame my practice in this thesis. First, I have been careful in the language that I have used regarding the connection between text and practice. I repeatedly state that this written thesis *supports* a portfolio of composition. The music does not simply exegete, or add a colourful artistic sheen to, the written set of assertions. As a source of information about my compositional practice, my music is significantly more lucrative the text. However, music is a very slippery research object: I cannot guarantee that it will communicate the same thing to every listener. Without the combination of text *and* musical practice, I would not have been able to generate my thesis. My primary means of delivering these claims is, therefore, expressed as a combination of text and sound. Each chapter of this thesis is based around a specific component of my portfolio; musical examples are peppered through the text, so that the information that is conveyed by specific sound events can be textually underlined; and music is used to evidence textual claims. This means that I have accepted a certain level of risk: if the work sounds terrible to the listener then the integrity of the message could be compromised; the clarity of argumentation is mediated by the sound quality of the work (and the taste of the listener). However, the costs are far outweighed by the potential benefits; the musical component of this work communicates relevant ideas that are inexpressible in text.

Second, in formatting this thesis, I have made simplified mappings of things that existed as more complex entities. Many specific things that were put into place to generate music stopped existing when the music ended. I cannot submit the concert events in their totality, as this would require me to have a very different level

of control over space and time than I can achieve with contemporary music technology. I have partially resolved this by submitted recordings of work, but there is a different level of detail implied by a concert and a recording. To aid this framing process, I have submitted materials that can provide information about how these music systems functioned. These simplified system framings allow me to hone in specific features of the system that may actually be obscured by the perceptual experience of a concert experience. Alongside the musical example described above, I have submitted visual representations of systems as block diagrams, to frame connections between system sub-component; short videos that show musical or code behaviours; bits of code that can be run interactively; screenshots of interfaces; and photos or videos of performers. Conceptually, I see this as a form of dimensionality reduction. This is similar to the process of making 'wax rubbings', by placing paper over a sculpture and rubbing it with wax to produce a cosmetic tracing of the original form: a three dimensional aesthetic structure reduced to a two dimensional framing. **All sound, music, coding and video examples - as well as my portfolio - can be found here, and were also submitted electronically alongside this thesis** (Please email me - address on title page - if you have any difficulty accessing the Drive link). Please note that this folder of practice is split into five folders, and their contents should be evaluated while reading the corresponding chapter.

three core definitions

This doctoral thesis is predicated around the idea that a ‘music system’ is a difficult thing to practically define. Due to this material complexity (Born, 2017), this chapter investigates how I am using the term to qualify a core component of music practice. I start by putting the idea of systems into a wider discursive context, by positioning this study in relation to *cybernetics*. This is followed by an evaluation of the various *analytical framings* that can trickle into my understanding of what music systems are and how they can be researched. This motivates another primary theme of this project: *abstraction*. In this context, abstractions are music system components that consistently appear across multiple different material framings of what music systems are. The primary claim of my work is that interesting things happen when these abstractions are identified, named and organised into new music practice.

cybernetics as a contemporary music practice

“Cybernetics is the science of control and organisation in complex systems” (Pickles, 2016, p. 1). Following the technological developments of World War Two, interdisciplinary researchers met in New York between 1941 and 1960. Despite their disciplinary divergence participants were surprised to note the commonalities that existed between their various topics of study. As they recognised similarities between the ways in which these various disciplines understood systems and control behaviour (Beers, 1994), these meetings eventually produced ‘cybernetics’: a single scientific discipline to better understand complex control systems. The field developed to eventually constitute a ‘second order’ cybernetics, demonstrating increased awareness of itself: a “cybernetics of cybernetics” (Mead, 1968). This extension focuses on “the process of observation (and of the observer) as much as the phenomenon being observed” (Ramage, 2009, p. 05), drawing the perspectives of those who use systems back into the picture. This differentiation between ‘first’ and ‘second’ order cybernetics isn’t a case of historical context or discursive trajectory, but to define different processes for understanding systems and different strategies for considering the relationship between humans and control (ibid). While deeper links will be examined further, second order cybernetics has a significant parallel with my own research, as I consider myself and my engagements with systems as core components of this study.

histories of cybernetics in music

Daren Pickle’s (Pickles, 2016) PhD thesis assigns a broad heritage between cybernetics and music. Citing Curtis Roads (Roads, 2004) on early aleatoric devices in Western music, such as Mozart’s oft-reported dice games (see also Stevens & Raybould, 2016), Pickles suggests that such approaches were likely foreshadowed by other ‘rules based’ approaches to improvisation. Moving forward, Pickles is keen to foreground the impact of mechanisation: “while such methods are interesting.....it is with the advent of technologies capable of mechanically or digitally representing formal processes.....that composers become more fully engaged in algorithmic, aleatoric, or generative procedures” (Pickles, 2016, p. 29). Technicity is then on a central component, as he foregrounds works that couple of technology and environment, alongside those resulting from complex heuristic process. A parallel between mine and Pickle’s framing of ‘cybernetics music’ (something that he uncritically defines as a genre of music. A thorough discussion of ‘genre’ is beyond the scope of this thesis, but Simon Frith’s 1996 work on the subject is worth a look) can be found in here: “(t)hese works are often reflexive or self-referential and outcomes are not fixed but instead adhere to a “class of goals” (Beer, 1995).....these musical systems can produce unintended or unpredictable outcomes, but each iteration (each run of the system) maintains enough sonic coherence to theoretically allow a listener to identify it as that particular piece of music” (Pickles, 2016, p. 45).

music and analytical framings

This consistency between iterations has a clear parallel with my approach to research. However, while Pickles is discussing multiple ‘runs’ of the system, my approach to iteration locates consistencies between different ‘analytical framings’ of what these systems are. So far, we have encountered multiple frames for analysing music. Born’s musical assemblage - the complex of all relational factors that mediate musical form - provides a highly detailed account of the things that are needed to explain how music happens the way it does. This approach to understanding musical form maps nicely to Cage’s (Kostelanetz, 2003, p. 69) assertion that “everything we do is music” and Murray Schafer’s (Schafer, 1993, p. 05) claim that the soundscape of the world exists as “a macrocosmic musical composition”. Both framings are similar to Born’s in scale: they each describe musical activity from an extremely broad vantage point. These ‘high level’ (i.e. broad and framing enormous detail) depictions break down in their durability when applied to ‘low level’ (i.e. simpler and limited details; things the performer can control) practices. When I perform solo on guitar, there is little reason for me to pay attention to such complexity: I simply don’t need to account for the universality of musical experience, or everything mediating factor that bears on sound production: I am more worried about what is literally and tangibly at hand. This doesn’t stop broader depictions from existing, it just pushes them out of my current frame of analysis.

‘the performance ecosystem’ as analytical frame

Somewhere between these framings sits Simon Waters’ performance ecosystem. Here, the sonic form of works of music is an emergent phenomenon, produced from interactions between people, technologies and spaces, thus framing music as a model of environmentally situated dynamical behaviour [Impett (2001); Di Scipio (2003); Waters (2007); Pickles (2016); Sanfilippo & Valle (2013)]. The theoretical underpinnings of this framing are practically extended (deliberately or otherwise) by the efforts of Owen Green (2008, 2013, 2014), Artemi-Maria Gioti (2018), Tina Krekels (2019), Martin Parker (Parker, 2013, 2019), among other composers who fixate upon interactions between people, technology and place. However, analysing any such practice with any rigour (i.e. to specifically determine *how* sound is produced by interactions) will reveal a very different framing of what the system is. Artemis Gioti’s (2018) work for human and robotic percussionist is extremely different to early iterations Nic Collin’s ‘Pea Soup’ (1974), for the simple reason that Gioti used computers and the earliest implementations of Davies’ work did not (see Waters, 2007). Although each of these works can be framed as a performance ecosystem, their systems are radically different to each other in material complexity. The specific details that are framed (in or out) when describing a system will vary according to the material considerations and hand.

analytical complexity

“(I)t is much more natural for us to say that a war was triggered for religious or economic reasons than to try and imagine a war as a vast pattern of interacting elementary particles and to thinking of what triggered it in similar terms - even though physicists may insist that that is the only “true” level of explanation for it, in the sense that no information would be thrown away if we were to speak at that level. But having such a phenomenal accuracy, is...not our fate. We mortals are condemned not to speak at that level of no information loss. We* necessarily simplify, and indeed, vastly so. But that sacrifice is also our glory. Drastic simplification is what allows us to reduce situations to their bare bones, to discover abstract essences, to put our fingers on what matters, to understand phenomena at amazingly high levels, to survive reliably in this world, and to formulate literature, art, music, and science” (Hofstadter, 2007, p. 35).*

As shown, music systems can be described according to varying levels of complexity. Lower-level analytical framings necessarily reduce the complexity of musical experience and package it up into a useful model for operating upon the work. Due to this reduction of complexity, we can identify lower-level analytical framings as means of compressing the data size of higher-level analyses. Hofstadter (above) describes a similar process.

abstraction as information compression

My definition of ‘abstraction’ is aided by philosophers Alexander R. Galloway and Jason R. LaRivière (2017) (2016) in their discussion of digital data compression. With reference to Jonathon Sterne’s (2012) (2012) critique of mp3 codec processing, the authors use data compression as a metaphorical understanding of abstraction: material being transcoded from one form of data into another in such a way that it is possible to save space, thereby simplifying one’s set of affordances. This resonates with my discussion of analytical framings of music systems above. Complex musical phenomena can be reduced into simpler - abstracted - models for understanding how the event was formed. This reduction of complexity can be seen as a form of information compression: the complex assemblage of behaviours that initially formed the work is reduced to a scale that be more easily apprehended and controlled by a human. To refer back to digital data compression, this is a method identifying *redundancies* in the original signal. The specific manner in which these redundancies are dealt with depends on the specific way that compression is achieved.

To put this into a practical context, the following set of notes: ‘A3’, ‘C3’, ‘Eb3’, ‘Gb3’ and ‘A4’, could be compressed into the following (smaller) set of notes: ‘A’, ‘C’, ‘Eb’ and ‘Gb’, if the compression algorithm decided that the octave value of each note was unimportant. Conversely, the same set could be compressed into a representation of the data that took account of the starting note, the amount of notes in the set, and the interval between each note (as a list of semitone values), simplifying the set into ‘A3’, ‘4’ and ‘3 3 3 3’. This could be subsequently compressed by an algorithm that could identify redundancies in the list of intervals. If there is no change between the various items in the intervals list (as there is not in this example), then only a single interval value will be stored and applied to each interval value when reconstructed. This would compress the set as: ‘A3’, ‘4’ and ‘3’. Provided that the decompression algorithm behaved in a way that was correlated with how the data was stored, then there would be no information loss when the data was reformed. Finally, in an extremely lossy fashion, our list of pitches can be compressed into a single value: ‘notes’.

‘musically generative’ abstractions

This data value - ‘notes’ - is an compressed representation of the contents of the input list. Rather than keeping track of the discrete note values, our compression algorithm simply recognises that these elements are ‘notes’ and describes them as such. As well as describing lists of written pitches, this compression could be similarly be applied to streams of notes played in ‘real life’, i.e. by a kazoo or Theremin. Although these things make ‘notes’ in very different ways (the sound production mechanisms of a Theremin being different to those of a kazoo), they can still be usefully apprehended according to their ability to produce and control ‘notes’. This statement might seem overly glib - so bleedingly obvious that it is barely worth saying - but

this simple operation provides the basis for understanding how I am using the term ‘musically generative abstraction’. If the term ‘notes’ is an abstract container for any pitched sound event produced by anything that can reasonably convince a human being that pitched sound events are happening, then we can use this abstract container to describe an infinite quantity of complex and situated musical behaviour. ‘Notes’ encapsulates any note event that could reasonably fit into this category of universal experience: an infinite series squeezed into five tiny letters.

The idea that ‘notes’ is a meaningful carrier of musical information - one that is not limited to any single form of material representation - is evidenced by its ubiquity in certain compositional ideas. Note sequences, pieces, formal techniques, cultures and analysis systems (e.g. a diminished 7th arpeggio, a sonata, serialism, blues, Schenkerian analysis) are all predicated around the primacy of ‘notes’. Clearly, ‘notes’ is a ‘musically generative abstraction’. It persists across multiple analytical framings of what music is - written out in scores; clumped into aggregates like chords or scales; identified by digital tuning devices; talked about in pedagogical discourse; etc - and it can be used as a primary basis for forming new works of music. Moreover, the preponderance of this specific abstraction has led to analytical framings of music that deliberately shirk such ‘lattice based’ approaches (so called because scored pitch sequences conventionally occupy two dimensional grids denoting pitch over time), instead favouring stylistic conventions that are typified by a rejection of ‘notes’ (Wishart, 1996). Clearly, ‘notes’ is axiomatic to some framings of music practice and treacherous to others. The typology of abstractions that are favoured by composers is therefore a question of personal, cultural or stylistic value.

summary

I’ll end with three claims, which should be getting quite familiar: a) my compositional practice constitutes a music system that is too complex for me to finely control; b) this system is populated by ‘abstractions’, things that exist across multiple different framings of my practice; and c) interesting works of music can be produced by obsessing over what these abstractions are and organising them into new systems. I wish I could say that I composed my portfolio by following this process from the very start. As my supervisors, colleagues, friends and family will likely attest, it was a much more chaotic and indeterminate narrative, and often difficult to figure out what the hell I was doing until after I had done it. While ‘cybernetics’, ‘analytical framing’ and ‘abstraction’ were sticking out of my head throughout, the project was practice-led to the extent that I didn’t really understand what I was making until the majority of musical work had already been carried out. The following five chapters convey a slow and iterative comprehension of this narrative, as I lay out five abstractions that are (now) core to my understanding of how I want my music to be structured.

chapter 01: can I treat a person like a software patch?

‘Solo Guitar as a MaxMSP patch’ - the piece that this chapter supports - is a semi-improvised piece for solo guitar. This piece was made by forming a connection between the way that I play guitar and the way that I code in MaxMSP. A core thing that I do as a computer musician is define ‘presets’ that enable sets of parameter to be stored and recalled at will. This allows me to save types of sound that I like, and then retrieve them at an arbitrary point in future. The primary research question of this chapter - can I treat a human like a software patch - is used to contextualise this study in relation to my research into electronic music. Using myself as the ‘human’ test subject, I took a very simple interface concept from my practice as an electronic music and used it to generate semi-improvised music. All related practice can be found in [jackWalker_practice/chapter-01](#) (Click [here](#) for the Google Drive link). Feel free to peruse, but all featured content will be linked when needed.

In section 01, I begin with an overview of the piece. I put the work into a wider practical context by positioning it as a ‘semi-improvised composition’. This (almost self-contradictory) term is unpacked in relation to published critique of improvisation and composition, which leads to a more detailed discussion of how I composed the work as a set of instructions for improvisation. In section 02 I discuss the piece as an music system. My primary point of reference here are analytical and systems theoretical approaches that have emerged from the study of electronic music: Simon Waters performance ecosystem (2007) and Daren Pickles research into music and cybernetics (Pickles, 2016). I describe my piece in accordance with both approaches, in order to more firmly establish the relationship between my piece and electronic music practice. In section 03, I analyse the piece as resulting from ‘presets’ as musically generative abstraction. First, I discuss the piece as a set of ‘presets’: fixed and predictable playing styles, that can be named and easily returned to at will.

section 01: 'solo guitar as a MaxMSP patch' (2019)

this piece was originally called 'realisation' when presented in concert, but I realised that this is a stupidly general name for a piece that has a very specific musical concept.

This piece can be found here (chapter-01/01_soloGuitarAsMaxMSPPatch). Please listen before reading (or as reading if you are pushed for time).

description of 'solo guitar piece as a MaxMSP patch'

This piece resulted from a desire to treat my guitar like a MaxMSP patch. I took one very simple interface concept from my life as a MaxMSP programmer - 'presets' - and formed a semi-improvised piece around this idea. A 'preset' in MaxMSP, and countless other digital audio systems, defines a way of saving the state of set of parameters, e.g. the various controls of a software synthesiser. When presets are stored, they can be named, organised and retrieved in future. With a library of presets, the potentially infinite set of different combinations of synthesis parameters can be reduced into a simple set of options. I wanted to be able to treat my relationship to my guitar in a similar way. I evaluated various modes of making sound that I seemed to gravitate to while playing guitar and saved them as a short library of presets. These different performance behaviours could then be easily and predictably accessed. However, while this defined a set of sonic territories, it did little to suggest how I might combine these states into a musical structure. Remediating this, I sketched out a systematic way of moving between various presets. Due to my interest in indeterminate systems, I introduced some unpredictable behaviours into this procedural behaviour. The static library of presets that I defined were then given motility by this specific method of moving around between these states. The primary conclusion of this chapter is that this process allowed me to project a clear link between my practice as a MaxMSP programmer and my life as an improvising guitarist. This abstraction was generative enough to produce a work of new music, and, crucially, affords me a way of engaging with the aesthetics of systems-based music with a minimum of technological design. Given the over-fixation on technology that is well-documented in discourses around music and systems (Waters, 2007), this is a useful experiment to keep in mind.

improvisation

As a gateway into how I am defining the difference between the terms 'improvised' and 'semi-improvised', we can take a brief detour away from music. The streaming service Netflix recently (2020, 2022) released two television shows that centre around improvised performances. Although these examples are not musical, they are essential to the point that I am making: improvisational practices tread a line between free-form and ostensibly boundless improvisation on one hand and highly structured pieces, with rigid and prescriptive rules, on the other. I felt it important

to raise these ideas with an non-musical focus because it presents as a conceptually tidy case study, allowing me to set out the bones of the idea before I discuss it with regard to music. This lets me set out the basis of the idea without getting too bogged down in the various histories, scenes, techniques and theories that have sprung up around improvisation as a contemporary music practice (see [Bailey, 1993](#); [Krekels, 2019](#); [MacDonald & Wilson, 2020](#)). I use this to probe a deeper point. There is something that is touching and relatable about watching somebody think on their feet. My enjoyment in the two Netflix shows is similar to my enjoyment of improvised music; it's a perversely satisfying lens for human behaviour and spontaneous decision making (or people 'pulling things out of their arse', to relay cruder idiom). The fact that these two streaming shows were deemed financially viable by Netflix indicates that this type of voyeurism is wider cultural predilection. It is satisfying to know that there is an art in not really knowing what the hell it is that you are meant to be doing.

'improvised' or 'semi-improvised'?

'Middleditch and Schwartz' ([Netflix, 2020](#)) is a 'long form' improvised comedy show in which Thomas Middleditch and Ben Schwartz perform roughly an hour of completely improvised material: "Everything is made up on the spot - all jokes, all characters, all storylines" (ibid). The comics begin each show by giving a loose prompt to the audience 'can you tell me something that you are currently thinking about', members of the audience then shout suggestions out ('a wedding', 'a job interview', 'an exam'). The comics then hone in on whoever responded first and ask the audience member a series of questions: ('who is the wedding for / how did the couple meet', 'what is the interview for / 'how are you feeling about it', 'where are you studying', 'who are you studying with?'). After this brief exchange, the comics agree with each other that they can start, and the show is announced. The comics then proceed to improvise an hour long story that features themes, characters (i.e. people who were mentioned) and other details that were ascertained from the conversation with the audience member.

See [here](#) for a map of what this improvisational process looks like. The two stars take turns to create different characters - distinguishing them from one another with accents, or body language; placement on stage, or quickly darting about the stage to rapidly switch between characters and allow conversations between more than two people; with multiple characters often acted by both Middleditch and Schwarz at different times. It is very chaotic, and they very often break the fourth wall when they realise they have introduced a logical inconsistency to the plot (or break character in order to comment on the general absurdity). If we can identify a spectrum that spans from 'improvised' to 'semi-improvised', I would position this TV show closer to the 'improvised' boundary than the show that I will describe next.

Murderville ([Netflix, 2022](#)) (Netflix, 2022) is a comedy/murder mystery starring Will Arnett as homicide detective Terry Seattle. In each episode, Seattle must solve a

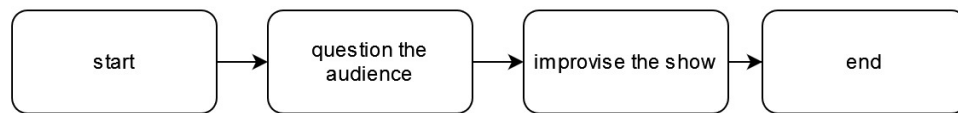


Figure 1: A visual map of Middleditch and Schwartz as an approach to improvisation

murder with a new partner, played by a different celebrity guest star in each episode. The guest is not scripted and must improvise their role as a homicide trainee. However, all other actors are given scripts (but must improvise responses to the indeterminate dialogue of the guest), and the overarching storyline is written in advance. After some initial exposition to introduce Seattle to his new partner and setup the investigation, the detectives gather a series of clues from the crime scene, and then go on to interview three suspects. At the end of each episode, the celebrity guest must solve the crime by naming the perpetrator by selecting one of the three suspects (the guilty party planned in advance of filming). If wrong, they are fired on the spot. If correct, they are congratulated and get to keep their job (until the next episode anyway).

See [here](#) for a map of what this process looks like. Core elements of the plot (i.e. the murder investigation, the suspects, and perpetrator) are defined in advance and all actors aside from the celebrity guest are given their lines ahead of time. Moreover, each episode follows a very specific formula: Seattle is introduced to his new partner, the murder investigation is prompted, the detectives interview three suspects, and finally the celebrity guest must name the killer. Moreover, the final presentation of each episode is edited with post-production content, such as dialogues, sound and music, meaning the overall experience is more cleanly relatable to a forty minute comedy drama than an improvised comedy show. While this allows a tighter sense of structure (and presumably more leeway to favour the more interesting contributions of the guest star), the improvising guest is clearly at the mercy of the format, and can only do so much to generate new structural information for the show.

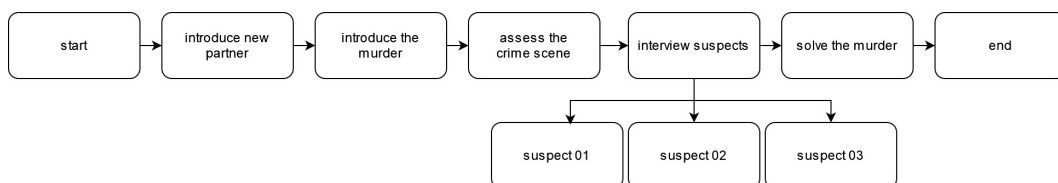


Figure 2: A visual map of Murderville as an approach to improvisation

semi-improvised composition

This idea of semi-structured improvisation provides the basis for what I define as 'semi-improvised composition'. Although elements of my piece were planned beforehand, the actual flow of musical events through time is to a large part deter-

mined by decisions that are made in the moment. Decisions around that production of the work in performance are able to “occur in real time and are contingent on a myriad of constantly changing variables” [macdonaldArtBecomingHow2020, 39]. According to guitarist and improviser Derek Bailey, since the 1950’s it is possible to identify compositional approaches that integrate the two concepts. He sees this as an attempt to “loosen the stranglehold” (Bailey, 1993, p. 60) that notation has over performers of composed pieces. Instead, certain composers afforded their musicians ‘the possibility of affecting the creation of music during its performance’ (pg 60). He considers this as “(i)ndeterminate composition, which might be described as any kind of composition in which the composer deliberately relinquishes control of any element of the composition” (ibid), but argues that this can take two forms: “aleatoric and improvisational”, defining aleatory as incorporating chance in compositional design - i.e. dice games etc - whereas improvisational approaches afford the players of the work some ability to make decisions as the piece is performed. Bailey cites a range of approaches to affording players this degree of ability to make these musical decisions, citing Earle Brown, Stockhausen and John Zorn as examples of such practitioners. Within the scope of options available to the player are a set of tools; something that Bailey calls a personal language.

In an example of such practice, improviser and guitarist Eugene Chadbourne’s (Chadbourne, 1993) medley of Coltrane arrangements played frantically on banjo, preceded by the statement: “Good evening y’all. This is North Carolina state senator Jessie Helms. It’s my pleasure now to play this medley by one of the true giants of bluegrass. From Hamlet, North Carolina, Mr John Coltrane”. While the specific way that Chadbourne planned this piece prior to performing and recording it could have been meticulously planned out on a note-by-note basis, it is much more like that he had some prior knowledge of the work and some chord charts of the harmonic changes throughout the Coltrane pieces that he refers to. The sound of the piece certainly feels like a semi-improvised exploration of the harmonic languages that Chadbourne associated with Coltrane, played using the stylistic conventions that are associated with the banjo - “bluegrass music” on one hand, and Chadbourne’s idiosyncratic approach to playing the banjo on the other. Supporting the notion that this is a semi-improvised piece is the way that Chadbourne seems to deal with mistakes. At 4’56” a tight metrical pattern starts to fall apart seems to lose its coherent pulse and is quickly followed by much faster sweeping flurry of notes before returning to the original pattern. This process sounds more like an improviser losing the beat, and then justifying the break in regularity with a more intense change, as opposed to a structural detail that was always going to occur at this point in the piece. The specific way in which this piece is formed as a structure results from this idiomatic interplay between the styles of jazz and bluegrass, and also from the interaction between Coltrane’s musical language and Chadbourne’s.

This system was made by identifying distinct sub-components of my own ‘musical language’ and naming them, so that they could be easily recalled at will. As a way

of setting out the general corpus of musical behaviours that I had access to, I have submitted four examples of myself playing guitar in an improvised way, in a variety of different contexts. This folder of sounds can be listened to in full or navigated around loosely to get a sense of the types of things that I do as an improviser. Each work within this folder was composed outside of the context of this specific piece (i.e. I was not thinking about 'presets' while performing), but were all carried out throughout the course of my PhD. While non-exhaustive, this small collection of sounds documents my musical language. [Please see here for this small set of improvised pieces](#) (chapter-01/02_threeImprovisations).

section 02: the piece as a performance system

How can I turn these stylistic elements into materials that can be structured into a system? To answer this question, we can take a more detailed look at how I composed ‘solo guitar as a MaxMSP patch’. As a means of performing a piece, the work exists as a) a collection of semi-improvised behaviours that can be recalled at will and b) a structured set of rules for connecting these behaviours into each other. This system was generated through a process of improvising on guitar and identifying the types of behaviours that I commonly referred to, so that I could sequence them through time in a semi-deterministic way. I improvised while playing guitar, found musical ideas that I liked and wanted to repeat, and then named them. With this set of materials established, I then had to decide how to move between these states of playing. I wanted to base the structure of the piece around transitions between pitched and noisy materials. I also wanted to implement a behaviour that would make the pitch content of the noisier segments harder to predict. I therefore decided that every time I would return to the harmonic materials I would have to de-tune my instrument. This meant that when I returned to the noisier elements, my set of affordances had changed. [Please see here sound examples of the presets that I describe in the following paragraph](#) (chapter-01/03_guitarPresets). As these examples make clear, the presets are loose boundaries that encapsulate specific types of performance behaviour. As the videos show, they are not particularly strict - as I often intuitively ‘break out’ of them, sometimes by accident and sometimes because I get bored or feel like I should be doing something different.

See [here](#) for a flow chart of how the piece is played.

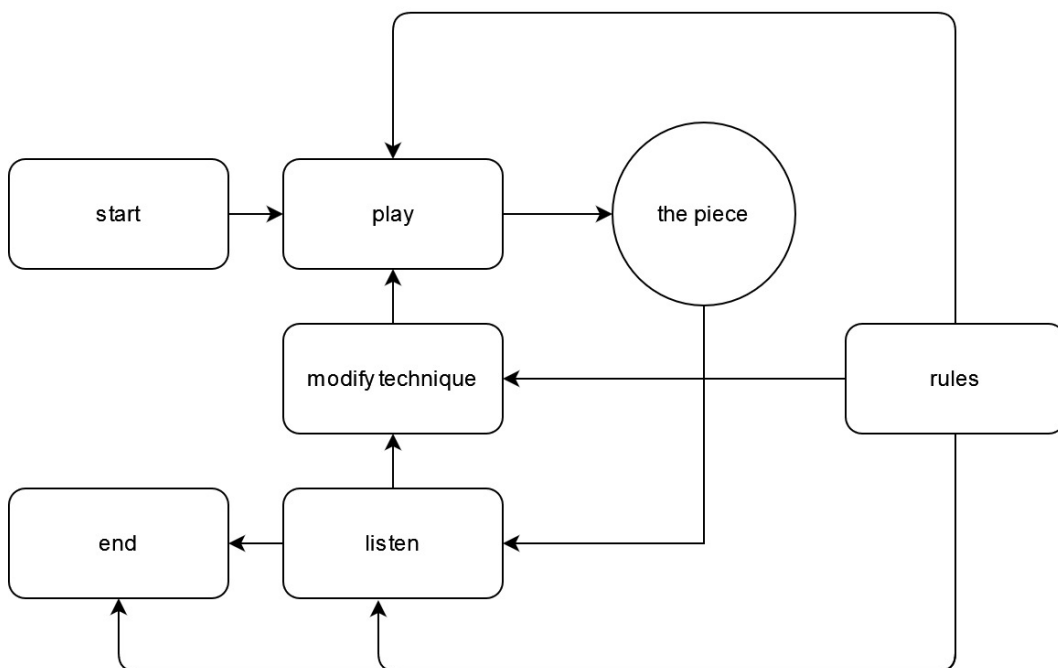


Figure 3: How the piece is played in performance

As shown, this piece had four core states: scanning, pulsing, harmonics, and detuning. I produced a structured way of mapping through presets. I decided that ‘harmonics’, generally speaking, had to be accompanied by ‘detuning’, so when I get bored or tired with the scanning and pulsing (the noisier and more fatiguing materials), I had to enforce a change in the pitch quality of the strings, meaning that I would have different harmonic options available to me whenever I returned to the other presets. I also alternated between using a plectrum and not using a plectrum, usually making this decision based on what ‘felt right’ at the time. Moreover, I had to ultimately reach something that I found to be a satisfying conclusion, before I ran out of time (monitored via a clock and the fifteen minutes that I allotted for performance). These rules were chosen to a) help me move through materials in a structured way, giving each instance of the piece some consistency, b) forcing me to play pitch content that I would not be able to predict (due to the fact that I had to detune my instrument), and c) give me a specification for finishing the piece (i.e. monitoring the clock and coming to a conclusive gesture before the end). Despite the fact that this process did not include a computer at all, the way that I approached this idea was informed by a study of how I approach MaxMSP programming, where I would typically generate structured ways of mapping through parameter presets in performance (see Chapter 03). While putting this piece into the context of computer music pay prove slightly challenging, given that I didn’t actually use a computer, the following section positions the piece into two theoretical perspectives that are commonly applied to the theorisation of computer music: the performance ecosystem (Waters, 2007) and musical cybernetics (Wiener, 2007).

description of the piece as a performance ecosystem

Simon Waters (Waters, 2007, pp. 01–02) claims that there is a pernicious tendency to occlude the social and cultural factors from electronic music practice, which is reified in a contemporary tendency to draw hard-line distinctions between the concepts of “performer, instrument and environment” (02). This manifests a reluctance to understand the complex network of interactions that span between these interrelating factors, and elide the mediatory input of social context: “the constraints and constructs upon which music depends are not only, not even mostly, to be found in the physical object of the instrument, but in the physiology of this particular (human) body, in the algorithms which operate in this particular piece of warm wet meat, and in the many relationships between all of these and a particular acoustic and social environment” (03). By analysing the relationship between the human, technological and environmental factors that constitute a specific musical performance, it is possible to identify a complex ecology of multidirectional interactions. The musical experience that is formed by this ecology cannot be predicted by an analysis of its components in isolation: to understand the sonic form of the work, one must account for the behaviour of the ecosystem as a whole. This is a framework commonly applied to electronic music practice (all case studies in Waters’ paper are

electronic music).

Although my piece was ‘low technological’ as compared to the works that Waters discusses (i.e. there is no significant technological component apart from my guitar amp), we can readily pick out a ‘performance ecosystem’ by analysing the concert recording of my work. The specific way that this piece was rendered as audio was defined by the social and technological conditions of performance. The sound technician for the concert gave me two microphones so that I could amplify the acoustic sound of my instrument (a request that I made), but decided what these microphones were. He also decided how my guitar amp be amplified and selected the amplifier. These elements were run through a mixing desk and loudspeaker system which I helped set up, but did not provide or choose placements for (which is good because Roderick Buchanan-Dunlop, the engineer, is considerably better at this than me). These decisions factored into my ability to play the piece - the form of the piece emerged from these interactions between myself and Roderick. From a sound reinforcement perspective, the specific arrangement of technologies drastically influenced the way in which sound was formed: it sounded very different in my bedroom in rehearsal. The acoustic of the space also had an impact on the way that sound was able to diffuse around the space. The size of the space impacted the distribution of people within it: the size of the space wasn’t only an issue of acoustic projection but also social expanse: the larger the room was, the more people were able to occupy it: this social presence had a psychological impact on how I was able to perform (Bailey, 1993; see MacDonald & Wilson, 2020).

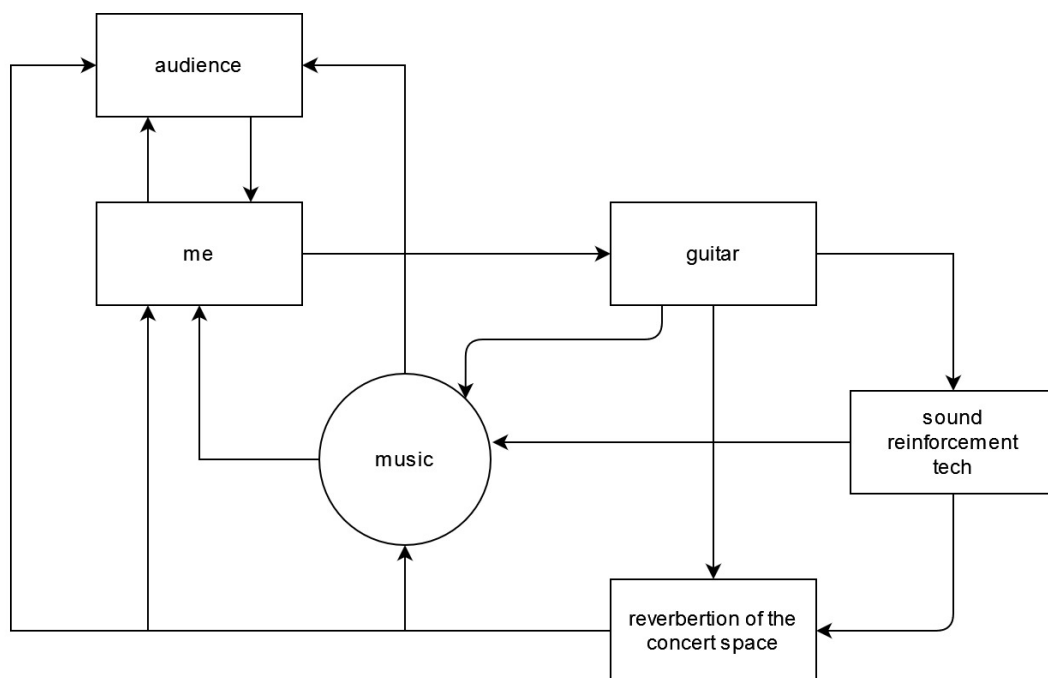


Figure 4: The piece as formed by a complex network of interactions

cybernetics of a solo improvisation

The audio recording of this concert resulted from a complex interaction between people, technology and performance space, contextualising it similarly to the electronics works of music covered in Waters' paper. See [here](#) for a map of this performance ecosystem. However, while this way of evaluating the piece certainly helps to embed it alongside the electronic music practices that are described in Water's paper, this explanation of how the piece functioned as a system is fairly shallow. The same set of interactions between performer and technology and performer and audience could be reasonably applied to any instance of improvised music. In order to achieve a more specific framing of how this piece operates in accordance with my practice as an electronic music, we can look more deeply at the specific dynamical behaviours of this music system.

Daren Pickles ([Pickles, 2016](#)), in a PhD thesis covering music and cybernetics, draws attention to three key concepts of cybernetics: feedback, heuristics, and recursion. "Feedback is the mechanism by which a system is able to reinforce or suppress stimulus without prior knowledge of an environment" (2016, 32-33). According to cybernetician Stafford Beer, feedback describes "the return of a system's output to its input, which is thereby changed. Positive feedback takes an increase in output back to increase the input; negative feedback takes back an output increase to decrease the input and is therefore stabilizing in principle" (Beer, 1994). Feedback is the means in which systems demonstrate some awareness of their environment and are able to behave in response to external conditions. In the context of my piece, feedback loops are established at multiple levels of design, by way of increasing the complexity of musical material that is featured in my piece. Heuristics as defined by Beer are "a set of instructions for searching out an unknown goal by exploration, which continually or repeatedly evaluates process according to some known criterion". This is opposed to algorithms which produce more predictable results; "instead of trying to organize it in full detail, you organize it only somewhat; you then ride on the dynamics of the system in the direction you want to go" ([Beer, 1995](#)) (Beer, 1994). Recursion refers to "recursive coupling, in which, by a series of feedback loops, all components of a system (including those that route out to – and back from – an environment) are linked; a change in one area of the system will affect all components of the system by incremental interlinked degrees." (Ibid) Although musical explorations of these dynamical systems behaviours are not exclusively tied to electronic music practices, it is interesting to note that all primary examples of 'cybernetics music' that Pickles features in this work use computers or analogue hardware.

We can identify these general systems behaviours in my piece. First, the system contained a feedback loop between myself and my instrument. See [here](#) for a map of this feedback loop. While designing presets for the piece was a process of playing my instrument and making value judgements about what I heard, so that I could find useful musical states and train myself to reproduce them in performance. Second, this process - and the process of mapping through the behaviours of the piece in

performance - was heuristic: I only had a vague idea about the types of musical structure that I wanted to create. Third, as evidenced by the way in which my system was coupled with the broader 'ecological' system that existed between the performance space, my instrument and myself, we can see how this piece operated as a recursive process. However, again, while this helps to position this piece alongside a coherent set of experimentations with systems - which I would commonly more closely associate with my computer music work - it does not specifically explain how my piece forms a link between my two practice as electronic musician and improviser. However, it does provide a useful framing of why I want this link to exist.

By describing my work in relation to performance ecosystems and cybernetics music, I map out two reasons why I *want* to see a relationship between what I do with my guitar and what I do with MaxMSP. First, there is something aesthetically engaging about working with volatile and precarious systems. As stated above, there is something engaging about watching people improvise. This is partly due to the risks that they are taking in performance - the experimental effect of witnessing improvisation makes one aware of the fragility of the underlying structure of the piece. Complex live electronics systems project a similar sense of precarity. The emergent behaviours that are put into place by the implementation of a system that is sensitive of its surroundings draws attention to the specific ways in which the musical form of the work is mediated by this complex range of external features. The idea that this structure could collapse at any moment is compelling. Second, I was interested in the prospect of exploring these ideas without a computer because of the over-fixation on technology that is repeatedly observed in discourses around electronic music. I wanted some basis for exploring the systemic behaviours that I associate with live electronics music without the cultural baggage of a live electronics system.

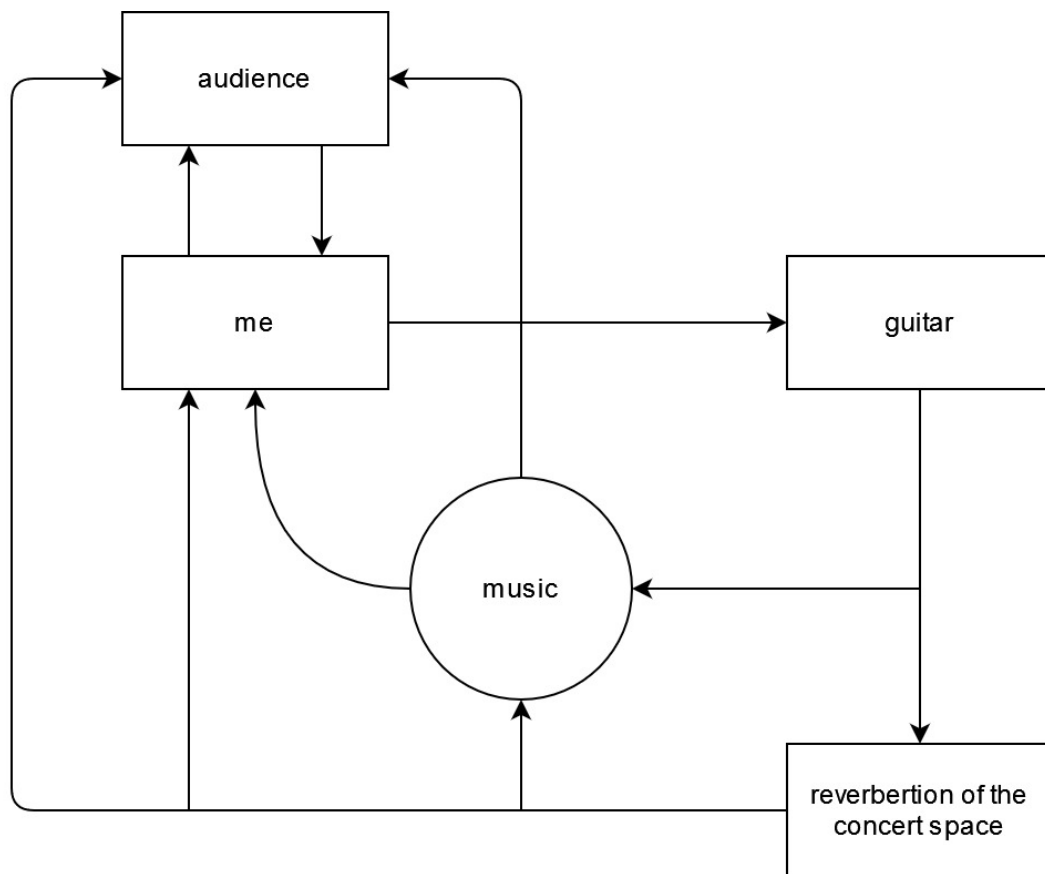


Figure 5: A feedback loop

section 03: presets as abstractions

This last point - the idea that the aesthetics of systems based types of music can be explored without a live electronics system - is musically supported by the correspondence between ‘presets’ as something in electronic musical interface design, and presets as they exist in this piece. In each case, they perform similar musical functions. In electronic musical interfaces, presets can be stored onto disc to make it easier to retrieve certain types of sound behaviour in future. This is a process of selecting and storing combinations of synthesis parameters. While the materiality of my approach is very different, in that deciding how to play guitar is a different task to arranging parameter values on a software synth, I was able to use this piece as a way of exploring this basis interface concept. The musical material for the piece emerged from the conditions that I implementing via this ‘presetting’ process, and the specific rules that I generated for moving between different presets in performance.

The primary ‘abstraction’ of this piece is ‘presets’. The piece was composed by evaluating ‘presets’ as something that is abstract enough to be understood as things that exist both in my practice as a MaxMSP programmer and my practice as a guitarist. Presets were used in this piece as a way of returning to stable and predictable musical behaviours. They served the same musical function as they would in MaxMSP. The primary idea here is that this worked as a systematic way of defining things that I wanted to hear, and then coming up with a procedural way of moving through them. As stated multiple times so far, defining presets is something that I commonly do in Max, e.g. as a way of storing parameter states so that they can be retrieved more easily in future. When this is done, I have a set of static sound materials that I reach for by instructing the patch to retrieve a particular preset. When I perform using this patch, I then have the option to move through different territories of sound by switching between different presets as the piece is played.

presets as music system components

In this section, I attach the notion of ‘preset’ to a broader music practical context, by evaluating the way in which electronic musicians refer to particular system states.

“The key is to find “pockets of magic” within the system: the places where all of the parameters line up, and where subtle changes between parameters result in compelling sounds” Pluta (2021), 6. In a paper presented at the Artificial Intelligence and Musical Creativity conference in 2021, Sam Pluta outlines his approach to exploring analogue synthesis systems using neural networks. Sam Pluta’s work ‘Neural Duo I & I’ (2021) produced using his NN_Synth_1 interface (2021) provides a method for storing large groups of parameter sets and then moving between them in non-deterministic ways using an analysis. This piece rests around his ability to save states onto disk and mapping through them in live performance. The design of Rebecca Fiebrink’s Wekinator (Fiebrink, 2017) is predicated on a similar idea:

Wekinator is used as a way of interpolating between preset states (2017).

We can also see presets as something that are used to produce other works of music. Rkss's 'Brostep in the Style of Florian Hecker' (Rkss, 2017). Using a bundle entitled "Loopmasters Present Dubstep Synths Massive Presets" (Loopmasters, n.d.) for the Native Instrument's synthesiser Massive, Rkss used these presets to refer to stylistic associations of 'brostep' - a diminutive term for overplayed and brash dubstep - formatted in a way that was intended to be reminiscent of the types of sound used in the musical work of Florian Hecker. As a brief but relevant aside, Rkss's project is a reference to a 'Acid in the style of David Tudor' (Hecker, 2009), an album released by Hecker in 2009, which projects a similar stylistic interplay, this time between the sonic conventions of acid house and the musical work of David Tudor. There is a parallel here to my own work, however the projected connection between my two target 'styles' (i.e. computer music and improvised guitar) is predicated around a technical similarity: I am fixated on forging this connection by systemising my response to my instrument in a manner similar to the way in which I would code features into a MaxMSP patch. While this link is incredibly tenacious - it is largely based around one small feature of the way that I use MaxMSP - this connectivity is, as we shall see, extremely generative.

listening back to the piece after composition

It wasn't until much later that I realised that this piece forced me to slowly move away from a sound that I have always found quite irritating when I improvise: the chord produced when a guitar is in standard tuning (E, A, D, G, B, E) without any fretted notes; something that I would describe as two stacked quartal harmonies split by the major third between the G and the B strings. As an improviser, this sound annoys me because it often occurs at moments when I am playing frenetically and strike open strings without meaning to. It also reminds me of hearing indy rock guitarists sound-checking their instruments while fiddling with amps on-stage. This shift away from these two reference points - the mistakes I make as an improvising guitarist and the world of rock and pop music - reveal a awkwardness to the piece that I remember feeling at the time. This was my first time playing guitar in an academic musical setting. It felt very uncomfortable; perhaps channelling a deeper level of imposter syndrome that I have felt in academia, which in turn possibly refracts the fact that I did badly at school and left at fourteen to study music technology at a place for kids who do badly in school. Pseudo-psychoanalysis aside, I remember describing my performance as an 'anxiety attack set to music' to someone who complimented me on the piece after the gig. One of my students at the time asked me if I know how to play guitar (straight-faced and, I think, genuinely).

Moreover, the act of forcing myself to find a set of playing styles that I liked and could reliably perform perhaps channels a need to find safe ground: states that I could reliably return to. This almost feels like a form of prosthesis - a way to adapt to the possible failures of my body. Derek Bailey describes this almost as a form

of safety net: comfortable patterns that can be fallen into easily throughout performance (1993). Almost paradoxically, I think another reason I wanted to shift the tonal possibilities of the work is that I would be forced into a harmonic landscape that I would have no prior awareness of; an indeterminate set of possibilities that I could explore without linking them to my pre-existing understanding of what a guitar is and how it should be used as a way of shaping harmony. My musical history is strongly associated with rock and pop convention, and I wanted to force myself into a position where I wouldn't accidentally play something that my 'imagined-ideal-contemporary-music-listener' (footnote: a complex idea that I explore in more detail in Chapter 03) would feel was 'banal', perhaps overly referential to functional harmony, and reveal myself to an imposter. I put myself into a position where I could only judge the merits of my performance on the sounds that it produced and the way in which I responded to them. There is something in this piece that deeply invokes a need to preserve things that I like and avoid things that make me feel uncomfortable.

conclusion

Although there are some marked material differences between performing with a computer and performing with no computer, it is possible to identify the act of composing a piece of semi-improvised solo music by using the same mentality with which I would approach the design of a MaxMSP interface. 'Solo Guitar as a MaxMSP Patch' was approached in such a manner. The semi-improvised form of the piece is based around musical ideas that were taken from my practice as a composer for live electronics: 'presets'. The presets were repeatable and predictable types of sound that I was easily able to attain in performance. Presets work to signify static sonic territories, meaning that I needed to implement mapping behaviours to allow me to move through these states through time. Despite the fact that the technological focus of this task was fairly minimal (as compared to the rest of this portfolio), my approach to forming this piece can be identified by using analytical frameworks that are more commonly applied to electronic music, namely Simon Waters' performance ecosystem and Daren Pickle's 'cybernetic music', despite the fact that the technological component of the work was minimal. This is due to the complex arrangement between myself as a performer, the technology in the performance space, and the environmental context of performance, as well as the way that my piece manifested concepts familiar to cybernetics. As the final section evidenced, my specifications for musical behaviours (my presets and control behaviours) are general enough to accommodate playing styles that have nothing to do with the piece as it was performed in concert. The core abstraction of 'preset' is a general element of my compositional practice, which can be decoupled from this piece and found throughout my portfolio of practice.

This final point evidences the primary claim of this research: that my compositional practice is a complex music system in itself. To generate a more thorough under-

standing of what this system is made out of is to develop a more robust interface for using it. As the recording of this piece clearly proves, this high-level systemisation is not a riskless endeavour. The constraints imposed by my approach to composing this piece may define the sonic and formal characteristics of the piece (thereby distinguishing it from a less tightly specified solo improvisation or a Eugene Chadbourne piece), but they also risk kneecapping my ability to develop new material. As evidenced above, my favourite moments of the piece are the encounters between rigid and specified musical behaviour and frantic bursts of aberrant sound; I fell deepest in love with the ideas that I was unable to explain. While I am satisfied with the piece as both a component of my portfolio and an example of semi-improvised solo music (although I personally wouldn't want that recording to last any longer), it also documents a need to further explore the complex barrier between planning and spontaneity as components of music system design. If this chapter has been fixated on static musical materials, the next obsesses over change, as I discuss a piece of music that I produced by observing the dynamic behaviour of a much larger entity.

chapter 02: how are clocks embedded into music systems?

TxH - the piece that this chapter supports - is a soundmap of a bitcoin transaction. This piece was assembled from a corpus of improvised material, performed on saxophone by Tina Krekels, plus guitar and synthesis by myself, a set of drum samples from Native Instrument's Kontakt factory sample library (n.d.) and a recording of a "Hapi Drum improvisational duet with Debby and Gordon Rosenberg" (Geerose, n.d.). I assembled these materials into a musical structure based upon a process of mapping out how bitcoin is transacted between different people. Different moments along the timespan of the transaction are represented by different musical events. Using Michelle Bastian's radical definition of what constitutes a 'clock' (Bastian, 2012), I use this piece to investigate how music systems use timing devices in order to control musical structure. All related practice can be found in jackWalker_practice/chapter-02 (Click [here](#) for the Google Drive link).

Section 01 begins with an overview of the piece. I then contextualise the work with reference to extant works of art that fixate upon 'blockchain' - the record keeping system that allows bitcoin to function as digital currency. I then draw temporality into focus by exploring Erik Christensen's theory of musical time. This is used to motivate the temporal focus of the piece. In section 02, I discuss the specific way in which I mapped out a bitcoin transaction in sound. This was a process of identifying the various social actors who are involved in transacting bitcoin (the sender of the coin, the receiver, miners and the bitcoin network). These different social identities were assigned different types of sound from my corpus, and sonically interact with each other throughout the process of 'transacting the coin'. In section, I discuss the primary theme of this chapter - 'clocks' - as a musically generative abstraction, with focus on the ways in which time is constructed and mediated by music systems.

If the previous chapter - on 'presets' - was obsessed with the storage and reproduction of desirable musical material, this chapter - on 'clocks' - disrupts this fixedness by requiring music to change through time.

section 01: 'transaction history' (2018)

You can find the work here (chapter-02/01_transaction-history) Please listen before you move on.

description of 'transaction history'

This piece is a sound-map of a bitcoin transaction. The structure and content of the work were generated by evaluating the way that a bitcoin transaction exists as a diachronic process. The overall process of the transaction is broken down in two ways. First, specific substages from the transaction (i.e. from producing the transaction via a bitcoin wallet through to confirming the transaction as a new blockchain record). These different stages are represented by different sections of the work. As a way of populating these different stages with sound, I assigned different corpora of sound to different participants in the bitcoin transaction. The sender of bitcoin, the receiver, the miners and the bitcoin network were all assigned different type of sound (details shortly below). These different 'social agencies', and the way in which they interact with each other throughout the piece, are reflective of the dynamic social behaviour of a bitcoin transaction; information is communicated between different parties until all agree that coin has been transacted. This technical and social mapping of a bitcoin transaction determined the structural behaviour of the piece. I started composing this piece by recording some experiments with saxophonist and improviser Tina Krekels, in which I invited her to think about the concept of 'value' before performing short structures on her instrument, and to then talk about what she just did. While this process produced too much audio data to reasonably submit alongside this thesis, [a rough overview of these sounds can be found in this video](#) (chapter-02/02_tina-montage), which provides a useful starting point for types of sound I was interested in during the early stages of composition.

I see this as a process of mapping between two different types of time. First, as stated, a bitcoin is a diachronic process. It has a formulaic character of behaviour as a set of operations that occur linearly through time. The actual 'clock time' of this process is indeterminate. A bitcoin transaction could take any number of seconds, minutes or hours to complete, and may get disrupted at some point along the process (loss of private keys meaning loss of access), or take a weird distended path to consensus (forks or similar). However, it is clearly possible to represent the progression of this task as an abstract temporal geometry, which I then fleshed out with sound. The type of temporal experience communicated by this sound is rather different to the temporality of bitcoin. Initially, it might seem like this major difference is due to fact that the work can be easily measured in 'clock time' (it is 5'15"). The structure of the piece, when listened to as music, generates a form of temporal structure in the perception of the listener. The specific way in which auditory events connect to each through time is a process of producing a) structured variations in sound pressure within the listening environment, b) a structured modulation of electrical

signals that govern sound processing in the brain, and c) unpackaging the encoded sound information into something that can be interpreted as musical structure. The abstract temporal format of a bitcoin transaction is therefore described as a structured pattern of auditory percepts.

artistic responses to blockchain

As a musical look at blockchain, this piece sits aside extant approaches to contemporary creative arts approaches to blockchain tech (Catlow et al., 2017). Within this quite loosely defined domain of artists who make art about blockchain, we can identify two rough types of practice. In the first type, practitioners use blockchain technology as a real-time (see Di Scipio, 2003 for an apt definition of the difference between real time and non-real time) presence in their work. This can include visual or sound artworks created by mapping live data from the blockchain into sound and visuals, or participatory approaches that invite people to play with blockchains (i.e. looking at and updating blockchain records) in installation work. In the second type, the artist imagines potential futures for the technology and presents them as fiction, via text, video, sound, etc. In this case, the technology is channelled in a more abstract manner; the imagination of the artist is used to anticipate potential futures for blockchain technology. In this category sit works of fiction which are written about the technology, as well as exhibition works which concern themselves with blockchain, but do not use the technology as an actual presence. This piece, as an exploration of blockchain that doesn't actually run the technology, falls into the latter category. However, while this helps contextualise the piece, it still does not explain the relationship between musical time and the timeframe of a bitcoin transaction. In Catlow et al's (occasionally quite idealistic) view, this is a process of bringing blockchain into the world as a thing that artists can have an impact on; while it is very difficult to know the developing impact that blockchain will have upon culture, it is possible to use arts practice to sketch out provisional engagements with the tech. This is to generate a culture around the technology that is predicated on the needs of artists rather than industry.

timescales of musical listening

"Music does not "unfold in time". Music creates time. A succession of musical sounds evokes sensations in time. The experience of musical time depends on the nature of the sounding phenomena, their relations and interactions. The experience of musical movement evokes sensations change and duration; the experience of musical pulse evokes sensations of regulated continuity and tempo. There are two qualitatively different kinds of time, called forth by the awareness of change and the awareness of regularity. They interact with each other, and they may interact with a third kind of temporal experience, related to sensations of gradual transformation which are so slow or indiscernible that they

are not perceived as movement." (Christensen, 1996, p. 48).

Erik Christensen claims that the perceptual tools that allow musical listening are based upon survival mechanisms that were initially developed as an evolutionary response to an environment. These abilities to engage sensorially with the world have translated to dimensions for perceiving the flow of musical information as "evoked by the experience of sequences and patterns of differences in timbre, pitch height, movement and pulse". These dimensions are measured across two fundamental scales of time: the microtemporal, constituting pitch and timbre, and the macrotemporal, constituting movement and pulse. These dimensions evoked in time through listening, and relate to one another in order to produce higher-order dimensions of listening. Movement and pulse rhythm producing the perceptual phenomena of rhythm. Moreover, these higher order dimensions of listening produce new dimensions in themselves. The relationship between pitch and rhythm producing the sensation of melody. He identifies various ways of defining the relationships between these dimensions of sound as producing shapes in sound: the dimensions of listening clumping together to form complex musical behaviours. All these things are produced via a complex networked relationship between these various components.

In order to more thoroughly define how this piece maps onto my title question - how are clocks embedded into my compositional practice - we first need to identify what I mean by 'clock'. According to philosopher of time Michelle Bastian, a clock can be any "device that signals change in order for its users to maintain an awareness of, and thus be able to coordinate themselves with, what is significant to them" (Bastian, 2012). I take this loose and abstract definition of what constitutes a clock as a rhetorical starting-off point. With Bastian's understanding, the behaviour of the Bitcoin blockchain is an immense source of socio-technological clock behaviour. The blockchain, as a set of incrementally increasing records with specific economic values attached to it, is a way of observing the way in which the bitcoin network changes through time. This allow users to coordinate themselves with this shifting and distributed consensus, and feel secure in the immutability of their stake in this economy. A singular transaction is a lower-level form of clock that is encapsulated within the broader behaviour of the blockchain as a whole. This is due to the way that a single transaction can be used as a reference point for the behaviour of the blockchain as a whole. The timeframe and technical process of a single transaction signals change in the blockchain record, and is used as a lower-level point of coordination with the currency. My piece attempts to fragment an idealised transaction as a set of behaviours that move through time and reproduce an abstracted view of this clocking behaviour by mapping it out with sound.

section 02: a soundmap of a bitcoin transaction

I described this piece above as a sound map of a Bitcoin transaction, and this work was generated by projecting a link between these two things. This was a process of describing the behaviour of a Bitcoin transaction in a way that I was capable of linking to the temporal unfolding of composition. This understanding views the map as something outside of time: something that can be described according to its constituent elements as a list of features that are always there. While these maps were used as a way of producing a musical structure that was in some way related to Bitcoin, this process of mapping extemporaneous things can be found elsewhere. However, this is not intended to be a literal transformation. While I am tempted to suggest that the structure of the work contains something of the dynamic of a bitcoin transaction - due to the way it follows it out as a process - I struggle to attach too much credence to the idea. As the following section reveals, the process of mapping out a bitcoin transaction in sound was extremely interpretive, and always tempered by an intuitive sense of what I wanted to hear, rather than a literal and rational approach to producing a useful map of a transaction. I doubt that anybody would hear this piece and immediately think “Ah, yes - it is Bitcoin!”. I simply took a process that was interesting to me at the time and used it as a structural guide for a piece of music. My abstracted bitcoin transaction therefore became another kind of clock. I mapped out the transaction as a way of signalling how my piece *would* change through time. This provides some basis for understanding how clocks are embedded into my music systems: they can exist as high-level *structural* guides for pieces. Furthermore, we can channel this to an understanding of how clocks exist on a *technical* level - as timing devices that are used to mediate the flow of sound in real time (i.e. metronomes, scores and .wav files are devices that can be used to regulate the flow of sound events). Finally, we can see these clocking behaviours taking place on a *perceptual* level. As argued by Christensen above, the act of perceiving music produces time, and we can understand his description of this as a way of orienting oneself to sound: musical listening is a form of clocking behaviour in itself.

See [here](#) for an overall representation of this mapping process.

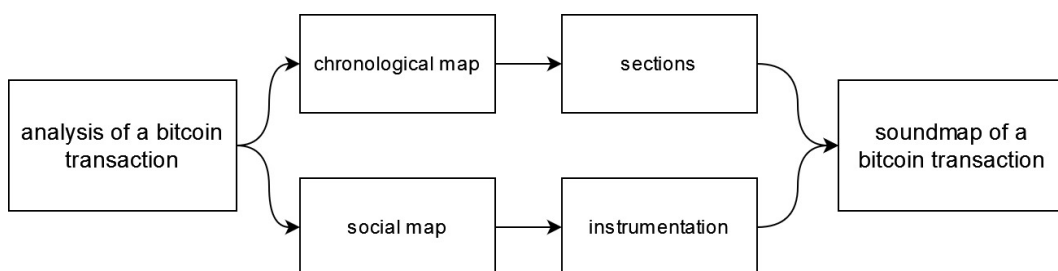


Figure 6: A sonic map of a bitcoin transaction

a bitcoin transaction

The interface requires the amount of bitcoin to be sent, the address that the bitcoin is to be sent from (owned by the sender) and the bitcoin address that the bitcoin is to be sent to (owned by the receiver). The transaction is then 'signed' by the wallet software using an encryption algorithm. This algorithm encrypts the data using a 'key' which is owned by the sender, meaning that no-one else could forge the signature, in a way that anyone who reads the transaction to verify that the data was indeed signed by the key's owner. The transaction is then shared across the bitcoin network, where it will eventually be picked up by a group of bitcoin miners. mining Bitcoin miners are responsible for verifying the digital signatures attached to transactions, in order to verify that the transaction is valid. Once they have verified a set of transactions, they form the data into 'blocks'. These blocks are then used as a data input for a particular kind of cryptographic puzzle, where the miners must receive a particular pre-defined result from a data-mapping algorithm known as 'hashing'. To hash a data object, e.g. a block of transactions, one inputs the data into a 'hash function'. The hash function will output a string of data which is determined through a complex computational analysis of the input. This output is deterministic; a single input to a hash function will always give the same result. However, one slight change in the input data will result in a drastic, and unpredictable, change in the output. The complexity and unpredictability of these calculations makes it almost impossible to determine a pre-defined result. This means that it is very unlikely that a hashed block of transaction will solve the puzzle. In order to find a winning block, one which matches the criteria of the cryptographic challenge, the miners append each block with a random number before it is hashed. Eventually, with enough attempts, a winning hash result will occur, and the block will then be considered 'verified', before being appended to the bitcoin blockchain and distributed across the network.

a bitcoin transaction mapped out in sound

We can relate this more generally to the process of forming sound by tracing patterns of non-musical phenomena. Nicholas Cook (2018) discusses *Symphony(Myths)* by Roger Reynolds (1990) as a way of producing a musical map of a non-musical formation. In Cook's account, Reynolds composed the work by analysing the visual qualities of two rocks that he encountered during his travels through Japan. The rock formation features a rock part-submerged in the ocean which has been tied with rope to another smaller rock. Reynolds developed a series of sketches of the rocks, each one analysing the geometric formation of the kinetic structure in different ways, and with varying levels of detail. He used this iterative process of analysing and sketching out the rocks to guide the parameterisation of a musical composition. Features identified by creating these sketches were used to define parameters such as harmonic content, rhythmical structure and instrument choice. This iterative method of analysing the rocks mapped out the musical quality of the work (2018). Cook argues that Reynolds toed a line between rational planning and intuitional decision

making.

His highest-level objective, to design a musical work in response to the rock, was comprised by a series of lower-level problems encountered as he mapped particular features of the rock to specific musical parameters. As Reynolds sketched with greater detail, these lower-level concerns became visually apparent on his sketch-pad. As soon as this happened, he was forced to think about how these particular mapping problems could be solved. He worked on these problems intuitively; his high-level structure gave him a guiding structure as he drilled deeper into lower-level specifications of musical form. The rational framework of his compositional process gave him permission to think and problem-solve intuitively. I argue that this process of forming the work from the rocks was a form of practice-led research. Reynolds composition taught him more about the structure of the rocks. He repeatedly interrogated the visual presentation of the rock from multiple perspectives, in order to learn more about the structure and how it could be described using sound. The material of the work resulted from this learning process, and contains structural details which would not have been achieved without the information ascertained from Reynolds' visual analysis. The decisions that he made regarding this musical material appeared intuitively as he dealt with specific mapping problems. He used his high-level compositional process to force him into a position in which he had to make these decisions. He used this process to learn about how he wanted music to exist in relation to the rocks. His analysis of the structure of the rocks taught him how he wanted to make music.

chronological map

The previous analysis can be broken down into the following five stages. Each part of this process is represented as a specific section of the piece. The five stages are as follows:

- section 01: the sender and receiver communicate in order to agree upon the terms of the transaction.
- section 02: the sender produces a transaction.
- section 03: the transaction broadcast from node-to-node over the bitcoin network.
- section 04: the miners pick it up and confine it within a block, before
- section 05 the block is verified and distributed back to the network.

See [here](#) for this chronological map.

social map

As stated above, I performed an analysis of the various human agents who take on a role within the process of a bitcoin transaction. See [here](#) for this social map. I

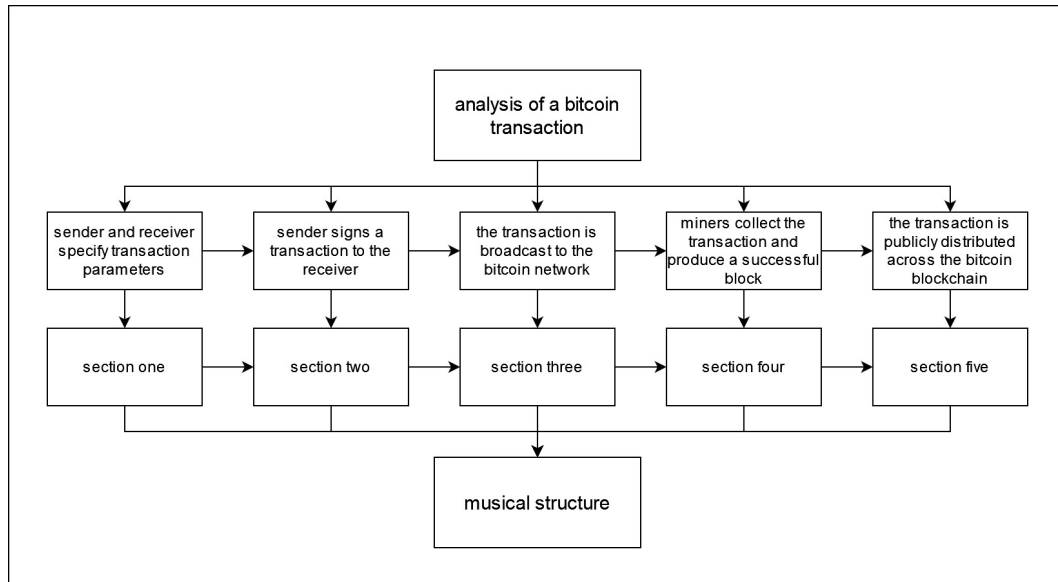


Figure 7: Chronological map of a bitcoin transaction

used each of these 'characters' to specify a particular class of sound material which is associated with this identity. I determined that there are four types of agent who must participate in a typical bitcoin transaction. These are:

- the receiver of the bitcoin: saxophone (*alien to me; sounds that belong to someone else*)
- the sender of the coin: guitar (*comfortable to me; sounds that belong to me*)
- nodes on the bitcoin network: gutter ([see here](#); Mudd (2019)) synthesis (*synthetic; complex and networked*)
- the miners: drum samples from the Kontakt factory library ([Native Instruments, n.d.](#)) (*produced for money; metronomic*)

Please see [here](#) for sound examples of these musical identities (chapter-02/03_identities).

section 01

The first stage of this process saw the receiver and sender of coin interaction in order to define the parameters of the transaction.

layer one: messages In order to express this communication musically, I wanted to convey the idea that the two classes of sound were providing information to each other. I edited a recording of Tina playing saxophone in way that slowly trickled in more information about the instrument that she was playing. To do this, I scanned through a recording and edited out any part in which it seemed that she was trying to produce sound. In this sense, I occluded any sound materials that sounded intentional. As understanding between the two parties grows, I began

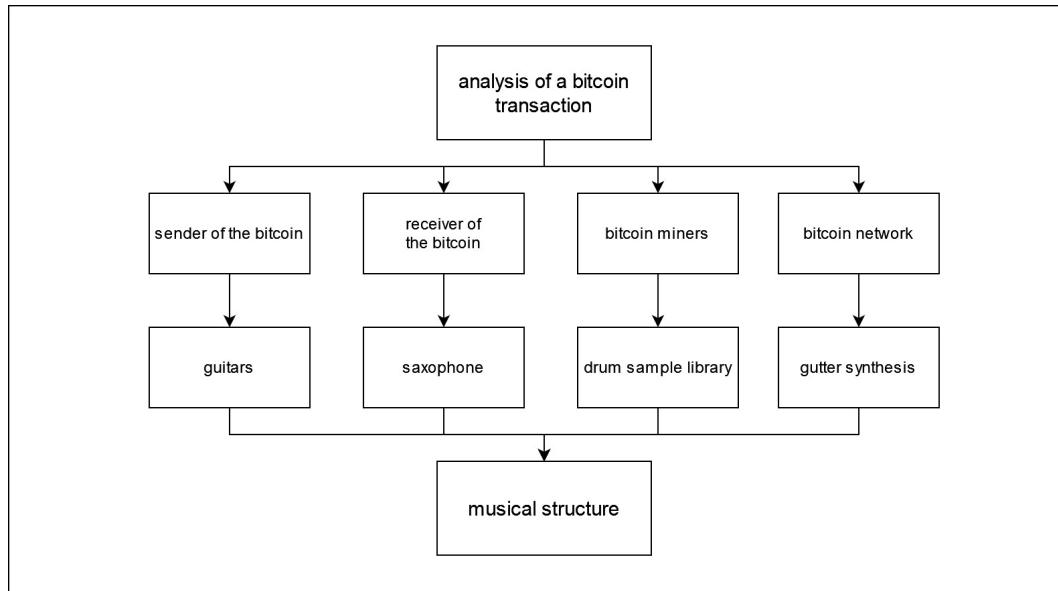


Figure 8: Social map of a bitcoin transaction

to trickle in more and more intentional-sounding sounds, eventually resulting in some verbal expressions from Tina.

Once the receiver had developed sufficient knowledge of the sender, they were then required to provide them with the parameters of the transaction. The first instance of this is a pitch heard on the guitar several times. This pitch represents the financial value which is to be transacted. Secondly, a bitcoin address for the sender is provided. I represented this with a short sequence, in which an amalgamation of bandpass filtered guitar sounds can be heard. This amalgamation of sounds describes the receiver's address.

layer two: environment The structure described above worked for me conceptually, in that it conveyed the information that I felt it needed to. However, I felt it to be lacking in environmental detail. It did not seem like the characters were communicating in a space. I decided to bed the conversation within the context of the bitcoin network by invoking the sound-class that I associated with this structure. I layered several harmonic structures underneath the conversation, and mixed them in order to heighten the narrative tension.

section two

In section two, the sender produces a transaction. This is populated with certain parameters: the senders address, the receivers address (established in sections one as a motif) and the amount to transaction (established in section one as a pitch). The sender then produces a digital signature by encrypting a hash of the transaction with their private key. I represented this 'hashing' of sounds with concatenation (see). The transaction is then sent to the bitcoin network.

layer one: rhythm The sender's address was represented with a reverse of the process that I used to gradually reveal information about the sender. Rather than attempting to edit out sections of the piece where it seemed the player was intending not to make sound, I edited to only include these parts. This resulted in a fast paced and frantic rhythm which I spaced out so that it formed a repeatable motif, which is heard at the beginning of section two. I use this motif to represent the sender's address. A pitch heard repeatedly in this section represents the value of the transaction.

I then represented the process of digitally signing the transaction in three stages. Firstly, I produced a hash of all sound heard up to this point. I then plunge the sounds produced by the saxophone into mild obscurity with a low pass filter. Finally, I snap back to another motif performed on the saxophone. This motif is roughly doubled up and split over the stereo field. This is to represent the fact that the sender is working with their identity expressed in two forms: their bitcoin address and their signature. Finally, I represented the sending of the address over the network with sounds that were suggestive of Tina's mouth working upon the saxophone. Conceptually, this worked for me as it suggested a change in the sender's attention, from the production of a transaction towards the communication of the message.

layer two: improvisation As this section progressed, I became aware that there was little reference back to the identity of the receiver. I decided to record new receiver-class material over on guitar whilst listening back to the sounds already produced. I increased the focus of these improvisations when the message is encrypted and when the transaction is completed (before the sending). This was to raise musical tension, and to hopefully remind the listener that the receiver's presence is there.

layer three: detail I again used gutter and Catart ([see here](#)) to produce some additional detail, which was placed without reference to my mapping device, and only when I thought it helped the other sounds to function.

section three

This section sees the transaction broadcast from node-to-node over the bitcoin network. This is the conceptually simplest section, and simply follows the transaction as it passes between several nodes on the network, before focusing in on the node owned by the bitcoin miners who process the transaction as a block. network This section is the simplest sonically. The passage of the message between the nodes is presented by a single harmonic structure developed using gutter synthesis which is split over several channels in a DAW. Each channel has a very narrow bandpass filter applied. The sound can be heard changing in spectral content as the relative gains of these channels are adjusted. The sound seems to move from one spectral space to another, and this represents the message passing through different net-

works. When the sounds passes through enough nodes, the entire network swells as a largely unprocessed instance of the harmonic structure is heard. This sound is then saturated with waveshaping distortion to increase its spectral complexity. Finally, the swell dies down and only one node-channel remains. Conceptually, This indicates the message passing between separate nodes and then becoming accepted over the entirety of the bitcoin network. Finally, it focuses in on the node run by the miners who process the transaction next.

Section four

During this part of the process, the miners process the transaction. The miners are represented with drum samples. A bass drum impact begins the mining process. A snare roll can be heard moving up and down in volume. Fluctuations of this seems to cause new material to emerge. New material referring back to the saxophone and guitar is heard here, and transforms in line with the miners effort. Towards the end of this section, a texture made of random generated gutter presets is introduced, and used to refer the method in which random numbers are created when miners are attempting to verify their blocks.

section five The block is added to the chain. After the final bass drum impulse, I deploy a new representation of the bitcoin network. This is manifest by a percussive duet that I found on freesound.com ([Geerose, n.d.](#)). Similar to the way that I represented the network in section three, this sound has been split over multiple separate channels and automated. This is representative of the successful block being passed around the network. The piece ends with a loud and distorted snare roll that continues for a short period of time. The focus is violently pulled back to the miners. It is impossible to ignore them. There is no mention of the sender or receiver; at this point they are relegated to history. The miners look forward as they continue to work on new blocks. The blockchain is maintained through time.

See [here](#) for a more complex view of this mapping process.

rational and intuitive processes

This piece was composed through a systematic process of mapping out a bitcoin transaction using sound. It should be clear that this process was not wholly rational. Through the preceding analysis, I describe a) decisions that were made as a way of adhering to the pre-defined structure of the work - i.e. 'rational' choices, and b) decisions that were made on an 'intuitive' basis as I listened to the piece and decided that things needed to sound different. A folder of sound examples, all taken from section 01 of this piece, illustrates this process well. The first sound is Tina playing without any editing (raw corpus material). The second sound is the end result of the rational process that I took to editing out the times in which it seemed like she was not using her instrument to make sound (a rational process described above).

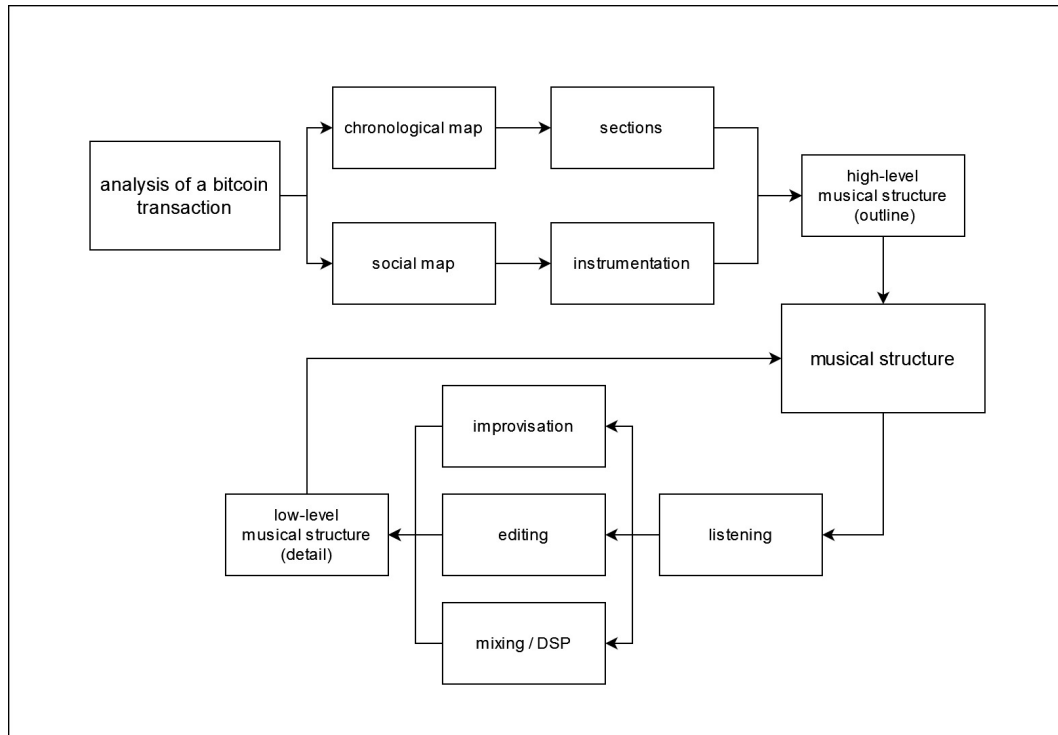


Figure 9: A more complex map of this mapping process

However, at this stage, I ‘cheated’, and started to introduce repetitive materials, by moving bits of the sound that I liked around the edit so that they could be repeatedly heard. The third sound is an extensive of this intuitive ‘cheating’ process, in which I create a short rhythmical motif. I then decided that this sound needed additional material, so then overdubbed some synthesised material over the top. Only the first part of this process was carried out as a result of my rational approach to structuring the work, and the three other decision making stages emerged from my own listening. While my mapping process provided a useful structural overlay for the piece, a huge amount of the musical character was predicated around these lower-level intuitive processes. [To hear how this process caused sound to change through time, please see here](#) (chapter-02/03_transformation).

section 03: clocks as abstractions

It is relevant to note that, while producing this thesis, I would commonly break days down into smaller chunks of time, that I would allocate to the completion of a specific task (a paragraph, a simple MaxMSP abstraction, some edits). I clocked this time in a variety of different ways, sometimes using a mechanical kitchen timer, my phone, my computer or a small digital kitchen timer. Other times (especially when working with sound), I used a large, twenty-five minute egg timer, that could silently alert me by providing a visual cue (transmitted via the displacement of sand). At other times, I used silence as a temporal cue: when writing, I would often listen to an album as I worked, and when the music stops, the task *should* be done. If it wasn't complete, I would have to work in silence. This is similar to the way that sound is used in video games as a way of punishing the player for taking too long to complete a task (see [K. Collins, 2008](#); [Stevens & Raybould, 2016](#)). Furthermore, I have taken irritated texts from housemates as a sign that it is probably time for me to stop playing guitar. Clocks are an intrinsic part of my working process, and they are not always metered in seconds, minutes and hours.

This piece can be seen as a relationship between two, Bastian-style ([2012](#)), 'clocks'. As stated, the linear temporal progression of a bitcoin transaction can be described as an abstract diachronic form and also as a structured pattern of auditory percepts generated through musical listening. Each of these things can be described as a form of clocking behaviour. The bitcoin transaction, communicates meaningful change via the transfer of money - something that practitioners of bitcoin transactions are likely to see as highly meaningful. The piece emerged from an ability to see clocks as things that are abstract enough to be understood as things that operate according to a vast degree of different material representations of time: through the slow and continual updating of blockchain records; the three hour booking in which I recorded Tina playing saxophone; overdubbing new improv over the piece, or iteratively mixing/mastering; the impacts of caffeine, weed and alcohol on time perception; deadlines; etc. This is musically useful because change is a core part of musical experience: time is the dimension through which instantaneous sound perception can be modulated into perceptual musical structure. The generative process of listening to music yields a new temporal structure, local to the perception of its listener. 'Clocks' are therefore musically generative. Moreover, they are a significant component of how people practice music.

clocks as music system components

How do practitioners implement time in their work? We can find a mix of technological and perceptual answers to this question in Road's *Microsound*. Aiming to "situate musical time within the broadest possible context", he ([Roads, 2004, p. 3](#)) identifies a great deal of different clocks that they could choose: "(a) central task of composition has always been the management of the interaction amongst

structures on different time scales. Starting from the topmost layer and descending, one can dissect layers of structure, arriving at the bottom layer of individual notes”. However, this understanding of time as an element of composed musical structure (i.e. notes and sections), does not account for the full temporality of musical expression: “Above the level of an individual piece are the cultural time spans defining the oeuvre of a composer or a stylistic period. Beneath the level of the note lies another multilayered stratum, the microsonic hierarchy. Like the quantum world of quarks, leptons, gluons, and bosons, the microsonic hierarchy was long invisible. Modern tools let us view and manipulate the microsonic layers from which all acoustic phenomena emerge. Beyond these physical time scales, mathematics defines two ideal temporal boundaries—the infinite and the infinitesimal – which appear in the theory of musical signal processing”.

He breaks musical time into nine categories:

“1. Infinite The ideal time span of mathematical durations such as the infinite sine waves of classical Fourier analysis. 2. Supra A time scale beyond that of an individual composition and extending into months, years, decades, and centuries. 3. Macro The time scale of overall musical architecture or form, measured in minutes or hours, or in extreme cases, days. 4. Meso Divisions of form. Groupings of sound objects into hierarchies of phrase structures of various sizes, measured in minutes or seconds. 5. Sound object A basic unit of musical structure, generalizing the traditional concept of note to include complex and mutating sound events on a time scale ranging from a fraction of a second to several seconds. *page 6*. 6. Micro Sound particles on a time scale that extends down to the threshold of auditory perception (measured in thousandths of a second or milliseconds). 7. Sample The atomic level of digital audio systems: individual binary samples or numerical amplitude values, one following another at a fixed time interval. The period between samples is measured in millionths of a second (microseconds). 8. Subsample Fluctuations on a time scale too brief to be properly recorded or perceived, measured in billionths of a second (nanoseconds) or less. 9. Infinitesimal The ideal time span of mathematical durations such as the infinitely brief delta functions.” (03/04).

In short, Roads provides a way of understanding the degree to which musical phenomena and the complex relationship between the physical existence of sound as acoustic pressure waves and the acts of human listening that translate to musical experience. In the context of my piece, I utilised the sound processing capabilities of my computer to operate upon these musical timeframes. These timeframes were in operation throughout the production of my work, and either engaged with tacitly, I.E. utilising the infinite while using FFT processors ([see here](#)), or explicitly when using the meso-level structure of the DAW to arrange audio fragments into larger cluster. Moreover, the form of the work emerged over a macrosonic period - as a function of multiple days and weeks spent moving material around and refining the structure.

While Christensen ([Christensen, 1996, p. 48](#)) claims that “Due to the variable balance between experienced changes and regularity and due to the complementarity between the transitory flow of musical sound and its retention in memory, musical time is flexible. Musical time is different from the regularity of measured clock time”. This statement could lead one to see a conceptual distinction between musical time as measured by listening and musical time as measured by a computer (i.e. sample rate); the temporality of the latter existing as something fixed and intrinsically regular. This idea can be contested with further reference to Bastian: “The idea that time is a fixed universal is thus both socially problematic and fundamentally inaccurate. Both the technical systems that produce time, and the experiences of time across wider societal landscapes, are far more complex.” She argues that clock time is a social process rather than anything that is objective. Drawing attention to a variety of ways of telling the time that do not include traditional conceptions of clocks, (below), she posits that clocks and watches are often seen as context-free and objective truth-tellers ([Bastian, 2012, p. 08](#)) “rather than as a contingent, context-specific convention” (2012, pg 08). Although UTC appears fixed and immutable, it must be modified if it is to stay in sync with ‘solar’ time:

“while the precision of atomic time would appear to have solved the problem of devising an accurate and consistent clock, atomic clocks cannot synchronize precisely with the rotation of the Earth, since this rotation is variable. This means that if we told time by the atomic clock alone, our clocks would eventually become desynchronized from solar time. In order to avoid this, the clock-time used in daily life is not actually a single form of measurement, but rather the result of an attempt to coordinate between two different kinds of time – International Atomic time (TAI, told in reference to the caesium atom) and Universal Time 1 (UT1, the successor to GMT which is told in reference to the rotation of the earth).” (2012, pg. 09).

listening to the piece in 2022

To Bastian, clocks are technologies that encapsulate value: the types of time that we prioritise in daily life say something about our values as human beings. How does this relate to the clocks that aren’t built into music systems? Bastian’s latter claim helps to demonstrate that even our most universal conception of time is flexible and socially contingent. The way in which we identify with clocks says something about the values that we have as human beings. I composed this piece in 2018. Listening to this piece today is a way of invoking memories that existed when I was working on it. Although a lot of detail has since been lost, I remember the initial process of carving up the saxophone line, the way in which I described the piece to the saxophonist. Moreover, the sound quality of the work is indicative of the values that I had as a mix engineer (nowadays I’d be more careful with clumping around the low end and use more expensive plugins). However, something else that strikes me when I listen to it now (in January 2022) is how the Bitcoin network has grown into something that requires more energy than some countries ([Aratani, 2021](#)), with

a concomitantly enormous environmental impact. This refracts something bleaker and less optimistic than the outlooks present in the works of Catlow et al (2017). The temporality of the blockchain isn't something that exists outside of the temporality of the world: it actively increases the pace through which environmental changes take place. This act of listening maps the timing of the piece to a much broader timeframe: the amount of time it will take global warming to take effect.

Choosing the types of time that composers wish to engage with in music systems is a stylistic and personal issue. From a broad perspective, the ubiquity of 'clock time' can be easily contested. The ways in which time is produced by perceptual systems and technological systems are more closely correlated than Christensen (1996) initially claimed. The specific ways in which composers implement timing systems will directly map to the types of things that they want their music to do. DJ's adhere to a metrical idea of time to be sure that their tracks don't slip away from each other while they beatmatch. Composers such as Marcin Pietruszewski (Pietruszewski, n.d.) standardise musical interfaces predicated on the idea that computational time is capable of sequencing microsonic events with precise enough regularity to carry over to the types of perception that he wants his listeners to adhere to. Musical time is a very different concept in GruntCount (Parker, 2013), a work and music system by Martin Parker, in which an improvising musician transitions through a library of presets at different rates depending on how many sounds they make, as compared to Michael Edward's (Edwards, 2021) Slippery Chicken composition environment, which allows users to tightly define the sequence of musical events, and then present this information via a score, MIDI control data, and/or set of sound files, among other representations. I draw attention to the idea that 'clock time' can be questioned, not because I think it is loose or inaccurate (clearly its intense reliability contributes to incorrect claims to its infallibility/universality). I simply want to state that any music system will produce its own types of time, and that composers can mediate this process - to an extent. Some temporalities will be controllable (e.g. asking a trained musician to gradually speed up a pulse), and others less so (e.g. how much ketamine your audience has ingested). The types of musical time that composers value on can be embedded into the tools that they use to create their music - a radical perspective on musical time may want to use this temporal slipperiness as a container of musical argumentation (as I feel Martin Parker, Eugene Chadbourne and Dawn of MIDI (Dawn of MIDI, n.d.) do extremely well).

conclusion

Although a recording of music can be seen as an immutable document of something that already exists, listening to that sound constructs new temporal structures. Perceptually constructed time evokes a complex ecology of temporalities that are external to the act of listening: the timeframes that can be rendered in the work can exist extemporaneously to the structure of the work as it exists as a fixed-length audio file.

Musical experience encapsulates this complex interface for networking with temporality. TxH is a unapologetically crude approach to this idea. The musical form of the piece is both a mapped relationship to a bitcoin transaction. However, there are connections between events that happen at different places. While this is typical of any musical work, the specific way in which these timeframes are threaded together is a direct result of how the piece exists as a system. The piece is a temporal map of a much more convoluted temporal process: the transaction of cryptocurrency, and the piece exists as a connection between my historical acts of composing the piece and the more general behaviour of a much larger system. The system of the piece deliberately invokes the temporal shape of a bitcoin transaction and mutates it into something that can be listened to in a shorter span of time. This connects to a wider field of practitioners who aim to use art practice as a way of learning more about how they want the technology to exist: an attempt to control the future of the technology. Moreover, it represents a means through which temporality can be built into systems. As we can identify from the work of Roads (2004), Christensen (1996), and Bastian (2012) - the different types of time that can be built into systems can be named and identified as general systems, although they exist in vastly different ways.

This final point augments the primary claim of this thesis: that my compositional practice exists as a complex music system, and that this thesis has afforded me a better basis for understanding it. As the audio file demonstrates, this process of modulating temporalities and forming the piece from these various encounters is not riskless: composers cannot account for every form of time present in their work. This is made starkly clear by the audio of the work: the most interesting moments of the piece for me did not come from the rational approach to working with musical time and representing a dynamical system behaviour, but from the moments that I worked with the piece - as sound - in the studio on an improvisational basis (a completely different temporal system). I cannot possibly account for the temporality of these experiences, but I was able to give myself some container to work within to allow me to produce this intuitive and chaotic stuff. Moreover, the senses of time that I was invoking will manifest in extremely different ways to different listeners. Regardless of how it appears to listeners, this work is a container for time; the rigidity of the rhythmic materials will produce their temporalities regardless of how much the listener knows about bitcoin, and the structure of the work is clearly a mutating form. If this work is indicative of change, the next describes the more complex changes that occur when static materials are given life through time.

chapter 03: assimilation or dissimulation? a sociotechnological feedback study

Assimilation / Dissimulation - the piece that this chapter is supports - was produced by myself and my colleague Aggelos Mastrantonis, and performed by the 'Rush Hour Ensemble', conducted by Peter Nelson, featuring John Konsolakis on clarinet, Richard Blaquiére on piano, Muang Luanghvisut on 1st violin, Georgina Finlayson on 2nd violin, Daniel Safford on viola, Justyna Jablonska Edmonds on cello and Russel Wimbish on double bass. The work was live engineered by Ana Betancourt, Roderick Dunlop Buchanan & Dee O'Leary, mixed by myself and Aggelos and mastered by myself and Roderick. Throughout this chapter, I argue that this work was produced by a strange sort of feedback loop that existed between myself and Aggelos. All related practice can be found in [jackWalker_practice/chapter-03](#) (Click [here](#) for the Google Drive link).

In section 01, I discuss the process of composing this piece. This section articulates the working relationship between myself and Aggelos, which, in later sections, is seen as the site of a complex social and technological feedback loop. To contextualise this, I discuss existing studies into feedback and music practice. In section 02, I interrogate the feedback loop that existed between me and Aggelos. In section 03, I discuss the primary theme of this chapter - feedback loops - in more detail, by evaluating the different forms of feedback loop that can be identified throughout this piece. Moreover, I use this section to critique the placement of feedback loops in musical practice more generally, and finally evaluate the musical outcomes as correlated to this 'musically generative abstraction'.

If the last chapter - on 'clocks' - was fixated on making things change through time, this chapter - on 'feedback loops' - turns this change into fuel: the patterned and ferocious cycling that is the lifeblood of complex dynamical behaviour.

section 01: 'assimilation/dissimulation' (Mastrantonis & Walker, 2019)

[You can find can find the work here](#) (chapter-03/01_Assimilation-Dissimulation_Walker and Mastrantonis). Please watch before you move on.

description of Assimilation/Dissimulation

This chapter supports Assimilation / Dissimilation. This collaborative piece was formed from a relationship that exists between myself and my close friend and colleague Aggelos Mastrantonis. Myself and Aggelos were given the opportunity to work on a piece together when we applied for funding to run a stream of events as part of Dialogues 2019. Before funding was secured, and before we knew that we would have our ensemble, we still wanted to work on a piece that would make the best of our respective skillsets. This meant that Aggelos would use his expansive knowledge of harmony to produce pitch relationships, and I would use my MaxMSP skills to make a live electronics engine. Early ideas for the piece included a duo for violin and live electronics, performed by Aggelos and myself respectively, and something that I believe we vaguely described as a 'gothy industrial techno thing' (at the time, I was very interested in producing a piece of beatless and tropish electroacoustic music that slowly gives itself auditory license to mutate into a hard gabber beat and back again). When funding was secured, alongside an ensemble which was assembled and conducted by Peter Nelson, we quickly decided to make a piece for the ensemble and electronics. As will be shown, the act of producing the specific materials of this work (i.e. the code and the score), was a continual negotiation between a) our *separate* abilities as composers, and b) our *conjoined* aesthetic interests. This mediation between differences and similarities between our sensibilities as composers traced an iterative process that eventually cohered into a singular musical work. The primary argument of this chapter is that this process was formed by a complex and sociotechnological feedback loop. See [here](#) for a simple diagram of this process.

collaboration

From one perspective, Aggelos was responsible for producing a score and I was responsible for designing a live electronics component. We both designed a small library of soundfiles that were played in performance (hereafter referred to as 'tape'). As a way of defining how we each understand the composition of this piece as a collaborative exercise, throughout this chapter I refer to two primary sources that were made by myself and Aggelos: - An artist statement that I produced on Aggelos's request in 2020 ([Appendix B](#)) - An artist statement that Aggelos produced on my request in 2021 ([Appendix C](#)) - These documents are used to trace the development of the project, with particular focus on how we each describe the work. Differences in our approach to writing about the project are used to motivate the primary claim

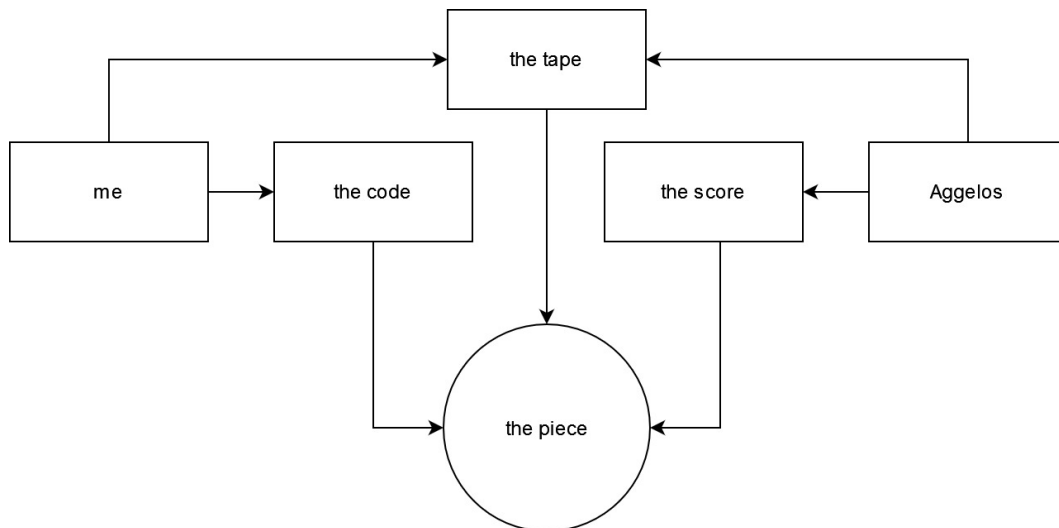


Figure 10: A diagram of how the piece was formed

of this chapter, which is that we had very different understanding of what the piece was - and how it was to be worked on - but were still able to produced the work as a singular entity. Before examining how this feedback operated as both a social and a technological phenomenon, I will first position in relation to extant studies of audio feedback in music.

From one frame of analysis, there was a clear separation between the roles of myself and Aggelos: I was responsible for designing the live electronics and interface component of the work, while Aggelos was responsible for producing the score. However, there was considerable overlap between our respective responsibilities, despite the fact their our approaches to composition are arguably very different. This chapter interrogates the collaborative aspect of this work, and considers the specific social relationship that existed between myself and Aggelos, nested within into a larger music system framework, that emerged concurrently as the work was formed iteratively throughout prototyping, rehearsal, performance and documentation.

feedback in contemporary music practice

“The type of feedback with which we are all most familiar, and probably the case that gave it its name, is audio feedback, which typically takes place in an auditorium when a microphone gets too close to a loudspeaker that is emitting, with amplification, the sounds picked up by the microphone. In goes some sound (any sound - it makes no difference}, out it comes louder, then* that *sound goes back in, comes out yet louder, then back in again, and all of a sudden, almost out of nowhere, you have a loop, a vicious circle, producing a terrible high-pitched screech that makes the audience clap their hands over their ears” (Hofstadter, 2007, p. 54)

Douglas Hofstadter traces a brief history in mechanical systems from early steam technology to heat seeking missiles and the ball mechanism that allows a flush toilet to automatically refill: “When the first mechanical systems with feedback in them

were designed, a set of radically new ideas began coming into focus for humanity. Among the earliest of such systems was James Watt's steam-engine governor; subsequent ones, which are numberless, include the float-ball mechanism governing the refilling of a flush toilet, the technology inside of a heat-seeking missile, and the thermostat" (51). Alongside drawing attention to the revolutionary practical affordances of feedback in mechanical systems, his primary argument is that feedback loops afford systems some ability to act autonomously. It follows that human users can ascribe some motivation to these types of dynamic behaviour: "It all has to do with the way the system's "perceptions" feed back (so to speak) into its behaviour. When the system always moves to a certain state, we see that state as the system's "goal". It is the self-monitoring, self-controlling nature of such a system that tempts us to use teleological language" (52). This "teleological language" allows humans to describe the systems behaviour according to the desires and motivations that the human projects onto it, rather than the physical makeup of the device itself.

There is a parallel between Hofstadter's brief history of mechanical feedback systems and Sanfilippo and Valle's (Sanfilippo & Valle, 2013) 'minimal history' of feedback systems in contemporary music practice. The authors in this latter study trace a history from experiments with cybernetics and systems theory that originated in the 1950's to present day incarnations of 'feedback music'. Early approaches to this type of composition include Pierre Henry, Roland Kayn, Robert Ashley, John Cage, Alvin Lucier, Gordon Mumma and David Tudor, who all, to the authors, made important contributions to the emergence of technological feedback systems as primary elements of composition. They trace the developments of this distinct compositional style from these earlier experiments to the contemporary practices of Agostino Di Scipio, Marco Cecotto, Robert Pugliese, Massimo Scamarcio, Simone Pappalardo and Alice Eldridge. Outside of the context of Sanfilippo and Valle's study, the Feedback Musicianship Network is an AHRC funded project into the musical affordances of feedback systems, again featuring Alice Eldridge, but also Chris Kiefer, Dan Overholt, Chris Chafe, Thor Magnusson and Tom Mudd. This project intends to help define "the right language to describe the behaviour of these radical new (feedback) instruments", to develop "new composition, notation and performance techniques, and new understandings of virtuosity" ("Feedback Musicianship Network," n.d.). Clearly, there is a rich and ongoing musical tradition that can be centred around the exploration of feedback as an element of musical performance.

technological feedback loops

Hofstadter's brief history of feedback systems is grounded in technology - he outlines various feedback loops that exist in mechanical systems and the complexities that arise when people use them. This technological understanding of feedback is continued by Sanfilippo and Valle's study (2013), where they focus on how feedback is achieved technologically (i.e. by loudspeakers, microphones, computers, signal processors, etc) and used by people to produce complex musical structures. The

Feedback Musicianship Network is again focused on technology, but instead focuses on the future directions of this form of music practice, by drawing practitioners together who use feedback as a technological component of new musical works, and investigate the impacts that this could have upon music culture. Assimilation / Dissimulation can be quite easily contextualised alongside these studies. A component of our live electronics interface was structured around the production of audible feedback loops using digital delay lines with high degrees of feedback. Inputs to this system caused each delay to oscillate at a certain frequency. The period at which each delay would resonate was set via a MIDI pitch value, allowing us to use this as a predictable form of musical feedback as a way of introducing electronic harmonic content to the piece.

However, as an investigation to the potentials of live audio feedback in composition, this system component is fairly unexciting. A scored (and therefore highly predictable) external sound input is used to generate a preset and highly predictable type of pitched sound content. While this was used to enhance the harmonic and textural content of the piece, the feedbacking behaviour of this element does not behave in the complex and macro-structurally generative manners identified in Sanfilippo and Valle's (2013) study. To more contextualise this piece as 'feedback music' in a more comprehensive and satisfying manner, we can identify a much deeper - and much more generative set of feedback behaviours. Rather than operating the entirely technological domain of our delay lines, these feedback loops existed as socio-technological structure: something that moves through human and technological channels of communication. Before evaluate how this loop was formed, we need to take a more tightly defined examination of a) how this piece existed in concert performance, and b) the compositional process that was enacted between myself and Aggelos in order to realise the score and live electronics of this work.

section 02: a feedback loop between two composers

We can examine the set of materials that are needed to perform this piece as a way of positioning it more firmly in relation to Sanfillipo and Valle's 'feedback music'. Performing this piece requires three elements: the score (instructions for the players), the code (the interface for the DSP), and the kit list of technology need to realise the performance (i.e. microphones, loudspeakers, cabling, etc - this is covered in the score and pages numbers will be provided). Moreover, in order for the code to behave correctly, someone - a 'live electronics operator' needs to interact with it in real time, so that the electronic sound will change appropriately as the piece is played. As the piece is played, whoever is controlling the live electronics is responsible for using a computer keyboard to trigger 'cues'. 'Cues' define three things: a) sounds played by the sampler, b) sets of pitches that are sent around the patch and used to define pitch control parameters, and b) presets for the delay lines and distortion processors. [To access the code and score, please see here](#) (chapter-03/03_code-and-score).

the piece as a performance system

The code is responsible for cuing and implementing changes in electronic sound material. It exists as a small library of MaxMSP abstractions for event sequencing and DSP. The code can be split into two layers. The control layer is the visual interface (*image*) that is interacted with by the electronics op to produce the piece. The electronics op reads the score as the ensemble plays and uses the buttons onscreen to change the electronics at the appropriate moment, or 'cue'. The DSP layer contains the electronic sound effects. This contains a network of delay lines that are arranged into a structured feedback loop. The time interval of each delay line was set by MIDI pitch data, meaning that specific pitches would be produced as sound began to feedback through the unit. This is used simulate fixed electronic pitched content from any unpredictable inputs that could be received from the microphones. It also features a bank of waveshape distortion units to heavily distort sound input. This distorted sound was then filtered by a bandpass filter, with its cutoff set to a MIDI pitch value. If the filter's resonance parameter was set to a suitably low level, and the input was sufficiently high in amplitude and spectral bandwidth, then any sound input would produce a fixed tone in accordance with the input MIDI value. Again, this allowed us to ensure fixed harmonic content from unpredictable sound inputs. It also contains ring modulation, additional wave shaping, and audio filters. These were primarily used to thicken the texture of the sound to taste. The musicians of the ensemble were responsible for providing input to these DSP effects. As a general rule, we assigned delay lines to string instruments; distortion and bandpass filters to the piano; and ring modulation to the clarinet. Finally, it features a sampler that plays back fixed length audio files.

See [here](#) for a representation of the interface for the code..

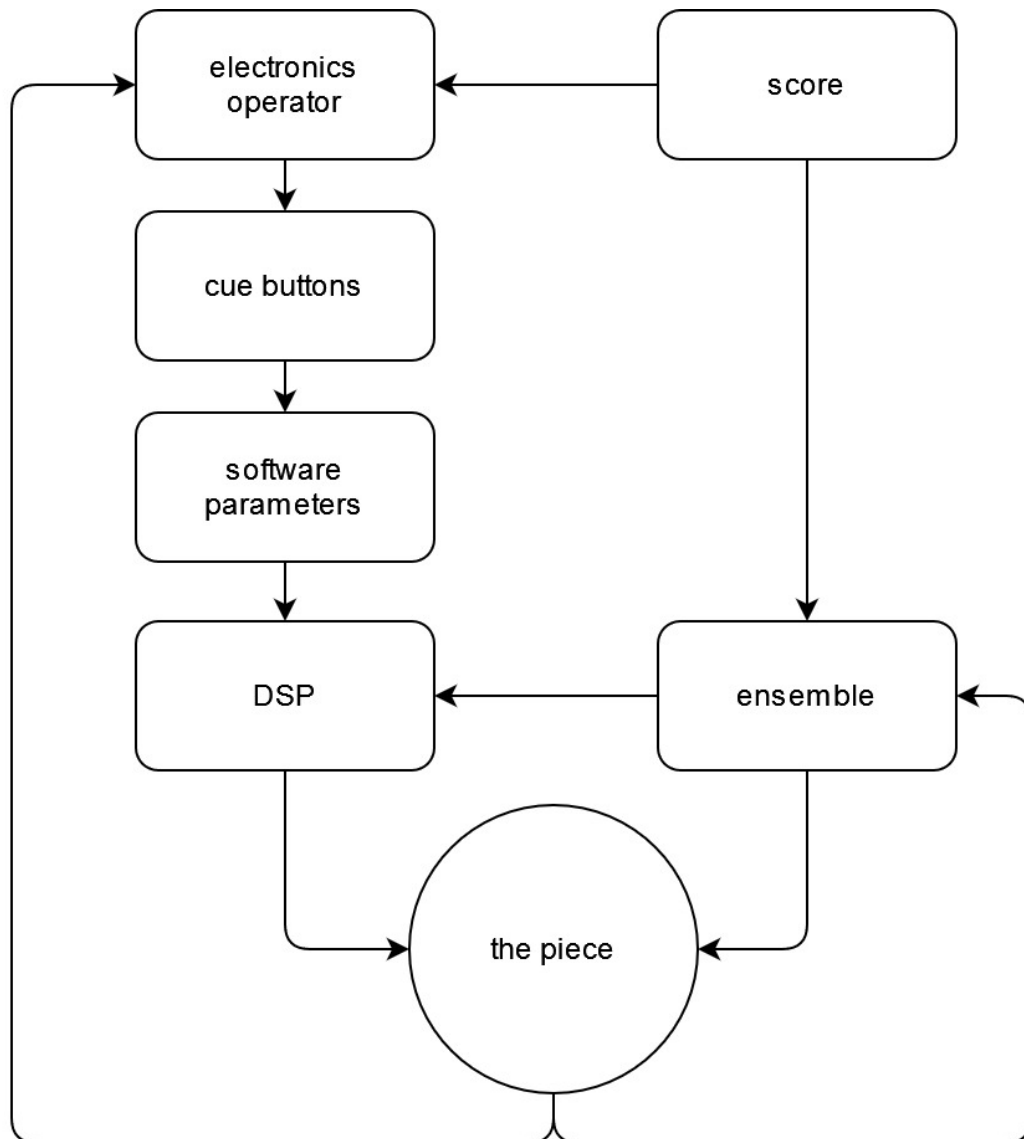


Figure 11: A representation of the software interface

assimilated live electronics operator

Moreover, further analysis of the way that the piece was mediated through performance reveals an assimilation between the musical behaviours of myself and Aggelos. Although our score of the piece (i.e. the instructions that would allow this piece to be played without the assistance of me or Aggelos)- calls for a single 'live electronics operator' to control the work, both myself and Aggelos fulfilled some part of this role during performance. See *image* for a diagram of this process. Aggelos was responsible for orienting the electronics within the timeframe of the score (i.e. he followed the score to identify the passage of cues), and I was responsible for interacting with the code to cause the sound of the electronics to change, while balancing the volume of the electronics via a small MIDI mixing desk. We can see a feedback looping between myself and Aggelos here. He took an input from the score, provided feedback to me on when I needed to act, I then responded to this call, causing the sound behaviour of the piece to change, which was then picked up upon by the ensemble, who responded to the electronics, meaning that I had the ability to modify the electronics of the work yet again. Despite this, the structure of the work was still fairly set in stone. The feedbacking nature of the work operated as a kind of harnessed chaotic entity, that was able to a very prescriptive set of noises, that were still ultimately predictable by myself and Aggelos. Contrasted with works described in the study above (Sanfilippo & Valle, 2013), this feedbacking behaviour was a reinforcement of what already exists, with few potential surprises.

To more fully investigate how the structure of this piece emerged from a *sociotechnological* feedback loop, we need to dig a little deeper into its construction. While the form of the piece was fairly well specified by the score (as a set of materials given both to the ensemble and the live electronics op), it is still worth considering how the form of the piece emerged from relationships between people, technologies and things that were implemented in live performance, i.e. in accordance with Simon Waters' model of performance ecosystem. While the harmonic structure of the piece will more or less function the same each time, we found that there were variations between each play through of the work (*example: sound from rehearsal and from the concert*). Moreover, the specific ways in which the behaviour of the instrumentalists provoked responses from the live electronics component also varied each time (*example*). The rehearsal process was an act of tuning the system into the behaviour of the instrumentalists and ensuring that we had adequate control of the piece while it was in performance. Although this work seems extremely fixed compared to the indeterminate behaviour outlined in chapter 01, the variations present in the work still demonstrates how this piece functions as a performance ecosystem. The following *image* shows a map of the complex interactions take took place in the performance.

See [here](#) for a diagram of how this piece functioned as a system.

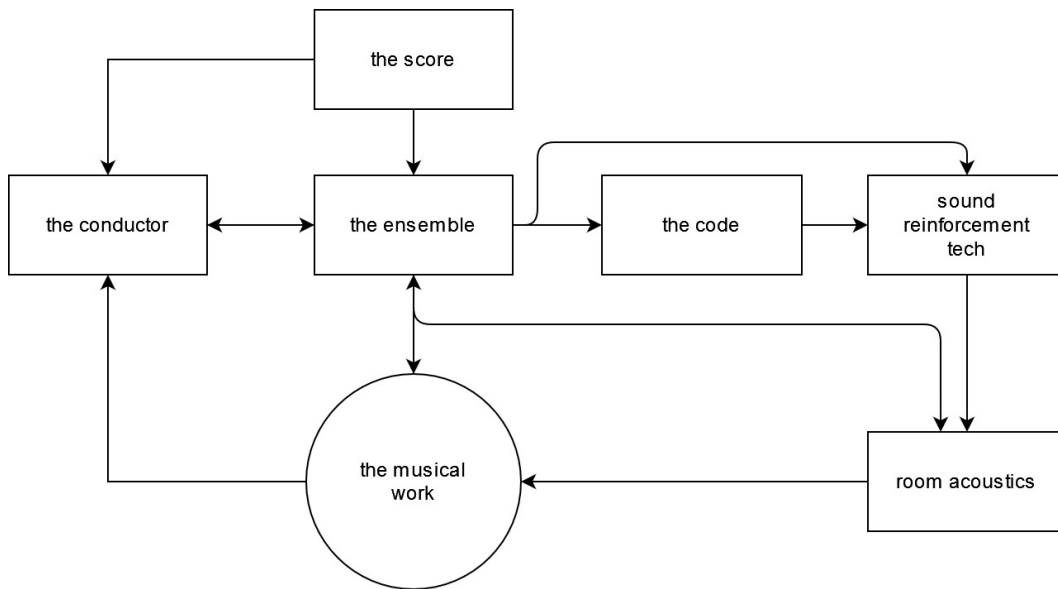


Figure 12: A representation of the piece as a performance system

cybernetics of a working relationship

While examining the piece as a feedback system in the moment of its performance provides some context for understanding the piece as a system, it does not fully anticipate the way in which the work was formed by feedback. To develop this focus, we can analyse two different perspectives on how the work was formed:

“Assimilation / Dissimulation is a collaborative work for ensemble and live electronics. We wanted to compose something which made the most of our respective skill-sets. I differ from Aggelos in that I have no significant background in music theory. However, I do have a lot of experience in computer programming for real-time digital signal processing (DSP). As I understand it, we wanted to compose a work with a fixed score and a set of live electronic materials which were capable of altering sound in real-time. Although there was considerable fuzziness and overlap between our roles, I was responsible for designing the code and selecting particular DSP techniques, while Aggelos was responsible for producing the score. Aesthetic decisions regarding materials largely originated in our respective domains.....but were mediated between the two of us. I like to imagine this compositional process as a feedback loop between two different methods of preparing sound for performance” (Appendix B)

as compared with:

“For our first tests/demos we booked the Alison House Studio. Jack was in the booth, and I was in the rec room improvising on the violin. The signal was processed via Gutter (the max subpatch developed by Tom Mudd) (*N.B from Jack: see here; Mudd (2019)*) and the generated output was returning as a feedback loop also directed by the code. The recording sounded like shit.....so we needed to see for a different strategy. We still wanted to use Gutter- mainly because it was so unpre-

dictable, fun to play with and niche interface as well - and then work with another system for the ensemble processing. This is what we eventually decided: Jack would run a series of short improvisational ‘shots’ on Gutter using a simple input (like bleep or a plain sine). We would record the audio output and then just would pick 1 or 2 excerpts, no longer than a minute long, that would pose as the main source for the piece, the epicentral sound, and the centrifugal force for both the generated score and any potentially additional tape parts.....I was responsible for producing the score, and Jack was responsible for the code. We wrote the tape parts together. But there was overlap in our duties. I mean to say. I can’t code for shit, but I can understand how I want live electronics to function, as mechanism in service to the work’s dramaturgy. Similarly, I believe that Jack might not be as familiar as I am with producing scores using notation programs, that being said, there were quite a few instances where I would receive feedback on the midi drafts, that read along the lines of: *‘The cello entry in bar 17 happens a bit to early here, we need less of an attack, faster crescendo and the glissando needs to reach A instead of B-flat. Clarinet is too loud as well. Passage might also work on a slightly slower tempo overall’*. Now, those are very precise directions; I would do the suggested changes and it usually sounded better indeed. I am not in a position to draw lines as to if directions such as these constitute scoring, or aid towards scoring- I suppose it is a question of causation and causality- yet it was good enough to edit specific parts and keep the ball rolling. My feedback to the audio files I was receiving in return, after the DSP or the interface, was also equally precise: *‘High pass this’, ‘Sounds too muffled’, ‘Too little overdrive here’ etc...‘* (Appendix C)

From these two analyses, we can see some core agreements from myself and Aggelos about how this piece was constructed. A thorough evaluation of every single transaction between myself and Aggelos is, of course, beyond the scope of this work (and likely beyond the reader’s patience). To proffer a window into the way that this loop formed, we can analyse the following sequence of behaviours (**This incremental feedbacking process can be traced by examining the contents of this directory structure** (chapter-03/04_feedback-loop). See below for further information):

- We began with loose experimentation, as a way of defining some common ground regarding how we would want our piece to sound. This was established by interacting with Tom Mudd’s gutter synthesis engine (**see here**; Mudd (2019)) and making a series of recordings. [Please see here for excerpts from the set of synthesised materials that we made together. The library was quite large, so I have played bits of it from a DAW. This helps describe the types of sound that we were interested in when we first started working on the piece. (https://drive.google.com/file/d/1nPbZ_NI52xv6BvCl3MezRvlzCeHC-i4E/view?usp=sharing) (chapter-03/03_gutterMontage).
- I uploaded a set of soundfiles (see above) to our shared Google drive that day.
- Aggelos analysed one recording we made using gutter and **expressed it as a**

table of pitches.

- This table of pitches was used by Aggelos to compose a short structure of music which was rendered out as a score and MIDI file.
- I took this, rendered it as audio, and built a MaxMSP patch around it (see the code and score, above, for a more complex representation of the type of patch I made: stream audio used as input for delay lines, filters and distortion units)
- Myself and Aggelos then interacted with this together, then, working alonge, Aggelos produced some more score/MIDI in response to his memory of the electronic sounds.
- I then took this MIDI, rendered it to audio, put this into a MaxMSP patch, analysed the frequency content of this and mapped it to the gutter synth, to modulate the behaviour of a new synthesised sound.
- Aggelos then took this soundfile and produced a [yet version of the score, which we mixed it with the new gutter material][<https://drive.google.com/file/d/1DS57k38lYvh>
- This feedbacking process continued until we stopped sending things back and forth between each other. How did we decide when this loop should end? Why didn't we keep doing it forever?

saturation:

Moving back to dynamical systems analysis, when discussing the exponential growth of audio feedback, Hofstadter raises the following theoretical problem:

“In theory, then softest whisper would soon grow to a roar, which would continue growing without limit, first rendering everyone in the auditorium death, shortly thereafter violently shaking the building's rafters till it collapsed upon the now-deaf audience, and then, only a few loops later, vibrating the planet apart and finishing up by annihilating the entire universe. What is specious about this apocalyptic scenario?” (Hofstadter, 2007, p. 54)

Framed another way, given the complex exchange of material data between myself and Aggelos, slowly accumulating in size and technical capability, why did our work not eventually grow to such an extent that it had absorbed all the world's media and sound production technologies until the world collapsed under the weight of it?

“Just as a floored car will not continue accelerating at a constant rate (reaching 100 mils per hour, then 200, 300, 400, soon breaking the sound barrier, etc.) but eventually levels out at some peak velocity *which is a function of road friction, air resistance, the motor's internal limits, and so forth), so an amplifier will not uniformly amplify sounds of any volume but will eventually saturate, giving less and less amplification until at some volume level the output sound has the same volume as the input sound, and that is where things stabilize.” (Hofstadter, 2007, p. 54)

The composition of this piece was constrained by reality. We had to produce the work in time for the concert presentation, and we needed the work to be around the length of time that we promised. External factors were responsible for defining the saturation point of the piece. Also, the complexity was constantly moderated by our need to keep the piece as something simple.

section 03: feedback loops as abstractions

“It has already been hinted that ‘Assimilation/Dissimulation’ worked as an additive feedback system on every level of production. The scoring was derived from and references the gutter audio file, which, in turn, was a byproduct of feedback loops. The pitch class sets of the delay lines were produced by the feedback cycles of the input’s delay and were themselves being emulated by the ensemble. The collaboration between Jack and myself had itself a fair share of back in forth in the exchanging midi files from notation program and audio outputs including the DSP. The slow pacing of the work’s progress was decided, stemming from a desired outcome which aimed towards a permanent re-orientational movement between the extremes of the work’s dual nature, via its palindromic motion either inside or outside territorial spectral class, amplification and contradiction, static and erratic, copy and simulacrum.” (Appendix C).

The primary ‘generative musical abstraction’ of this piece is ‘feedback loops’. This piece was generated by attending to the understanding that a feedback loop could be projected between two different working approaches. This necessitated the ability to see ‘feedback’, as a component of a music system, as something that exists technologically and socially. The piece emerged from these feedbacking interactions between myself and Aggelos, and the traces of this loop are present in multiple ways of conceiving the work as a system. The feedback loop between myself and Aggelos served a similar musical function to the loops discussed in cybernetic approaches to using feedback in electronic music systems. This is musically useful because feedback loops operate at multiple levels of conceiving works of music. We have already encountered a robust definition of feedback and a well-documented set of case studies that deploy feedback as a musical material, and encountered forms of literal audio feedback present in the interface of the work. Feedback loops existed within the delay lines. Audio feedback occurs in gutter synthesis. Moreover, this technological feedback is supported by social feedback loops occurring between myself and Aggelos in performance, and the broader still socio-technological looping of materials that eventually produced the score and code of the piece as a iterated and emergent substance; Aggelos enfolded into my way of making things, and I into his, with these two means of producing sound enfolded into one ‘piece’ of music that expressed a singular identity as a temporally unfolding sound event.

To examine the piece as a fixed form again, we can see a series of feedback loops that span between the score and the spectral content embedded into the recordings that we made of the gutter synthesis:

“(I)n ‘Assimilation/Dissimulation’ we are witnessing the total integration of the pre-existing material with its anacrusis from the separate medium (the ensemble) via a self-referential re-orientation. And it is through the abstraction between the two (model- replicas) that the movement of the piece is revealed. The ensemble constantly returns to imitating the audio file produced by the Gutter Improv (I think

we called it ‘high- 01’ or some similar really-not-so-sophisticated name) not only in regards to pitch and envelope, but also at the sample’s imperceptible rhythmical motion and modulation. Each time the ensemble attempts to mimic the sample, the result produces a different output, as it is similar and, consequently, not the same, hence developing opposing relationships between the replicas themselves. A relatively small alteration, or intentional ‘flaw’ in each copy- regarding even one parameter e.g. pitch- might result in a harsh dissonance at the moment of juxtaposition with the sample, moving from enhancement and amplification to conflict and dynamic abstraction.” (Appendix C)

feedback loops as music system components

Musical uses of feedback are already well-explored by Sanfillipo and Valle (Sanfillippo & Valle, 2013, see above). However, as already stated, the types of feedback system that are discussed are mostly orientated around technological approaches to working on music. The following section will outline some other perspectives on feedback loops as components of musical practice. First, from a self-interested perspective, we have already encountered a type of feedback loop in my ‘methodology’ chapter, manifest in my iterative process of making something -> evaluating it -> making it again. When working on sound, this practically translates to the task of making something (i.e. performing an edit in a DAW), listening to it (i.e. through sound playback), and then re-performing the original task if necessary. Moreover, the middle stage of this practically oriented feedback loops - i.e. ‘listening’ nests yet another feedbacking behaviour. The task of musical listening in itself is a recursive and iterative process. Erik Christensen’s theory of musical listening documents the processes through which we generate musical significance. In this looping process, listeners take in auditory stimuli, evaluate the evaluating their contents for particular perceptual features (i.e. changes in pitch through time), and then use this information to make value judgements about successive sounds that they take in.

On a similarly physiological basis, Raymond MacDonald and Graeme Wilson (2020, p. 32) explore the cognitive models through which musicians generate new musical material on an improvisational basis, recounting Jeff Pressing’s research into the subject:

“In one of the most influential cognitive models Pressing (1988) presents a three-component information-processing model of improvising. This account involves sensory input, information processing, decision making, and motor output. The primarily physiological processes discussed include neurological and hormonal changes involved in improvising. Also described are the various fine grained and complex motor co-ordination tasks involved including how muscles, bones, and connective tissue execute the electrical instructions. Once the music is produced, sensory feedback mechanisms (auditory, visual, proprioceptive) create a constant and very rapid feedback loop. An-

other feature of Pressing's approach is a focus upon the development of musical ideas in terms of melodic, harmonic, and rhythmic phrases that are constructed, executed, and critiqued rapidly by the improviser as part of the feedback processes outlined previously" (MacDonald & Wilson, 2020, p. 32).

Also on improvisation, Derek Bailey (1993) discusses the feedback loops that occur between audiences and audiences: "the effect of the audience's approval or disapproval is immediate and, because its effect is on the creator at the time of making the music, its influence is not only on the performance but also on the forming and choice of the stuff used....Undeniably, the audience for improvisation, good or bad, active or passive, sympathetic or hostile, has a power that no other audience has. It can affect the creation of that which is being witnessed." (Bailey, 1992, 44). Extrapolating from Bailey's account, there exists a feedback loop spanning between the musical sensibility of the improviser - expressed as the types of materials that they perform - and the receptive capacities of the audience - manifest by their taste and transmitted back to the player - which has a concomitant impact on the types of materials that they continue to perform.

From this latter point, it is clear that the existence of a musical work - as something that can be consensually agreed upon by multiple different parties - is negotiated by this complex feedbacking relationship between different people. In Bailey's case, while both the musician and the audience are aware that music is being produced, the specific values that they attach to this musical work can be strikingly different. Moreover, responses generated by either party (either through musical self-regulation on the part of the musician or positive/negative audience responses) can impact the musical outcome as experienced by both parties. Despite the fact that the musician and audience will see the work in different ways, they each participate in attaching meaning to it, which can then materialise into a shift in musical quality.

This idea that the piece was a very different thing to different people resonates with another claim of MacDonald and Wilson "(s)ocial construction of improvised events means that we cannot assume that improvisers must understand their interaction in the same terms" (MacDonald & Wilson, 2020, p. 105). This latter point is relevant to the compositional process documented in this chapter. Although myself and Aggelos approach and comprehend music in different ways, we were still able to construct the piece as if it holds a singular identity. Indeed, the musical specificity of the piece as it exists in 'objective forms' (i.e. materials that could widely be comprehended by a large number of people - the length of time, the pitch content, the types of sound processing) emerged from musical feedback loops that appeared between our different material conceptions of what sound is and how it can be worked on, a point that I will cover more forensically in the remainder of this section.

listening to this piece in 2022

“Without going into too much detail regarding the scoring, and returning to notions of self-referentiality, transcription and imitation, during the opening gestures of the piece, the ensemble produces pitches that correlate to the common tones between the 2 harmonic series (see the B $\frac{3}{4}$ flat and the open D string of Double Bass and Cello parts correspondingly, in the first few bars), while in bar 13 this material is distributed among strings and clarinet as the audio sample ‘high-01’ is triggered. In bar 100, at the point of the ensemble’s re-entrance, by doubling the super-minor 7th resonance of the tape part, the function leans towards a subdominant/supertonic affect. Compared to the common tones pitch set (‘table of spectral materials’ page 1), the pitch class can be understood as a transposition of the 2 upper common tones (a major 2nd plus a $\frac{1}{4}$ tone above the displayed table registers, and thus the supertonic vibe) with the transcription’s inverted low tone (D moving to E) now as the upper layer, displayed by Violin I from bar 106. The Hidjajj (or double harmonic) tetrachord formed by the dry signal strings from bars 138-139 was derived from the mid registers of delay lines of set no. 4, also referencing the ‘high 01’ sample (if we alter registers and re-configure B $\frac{1}{4}$ sharp to C $\frac{1}{4}$ flat). The piece concludes with the tones E on Violin II and F $\frac{1}{4}$ sharp on Double Bass from the common tones of the 2 harmonic series and B $\frac{1}{4}$ sharp on the Violin I (with Viola doubling 3 octaves bellow) and G (Clarinet) replicating the ‘high-01’ audio excerpt, in a sense attempting to synchronize and consolidate features from the 2 distinct sonic territories for the work’s epilogue.# The above were mere examples of the ensemble producing materials in concordance with pre-existing sonic features and spectral resonances, heard throughout the piece as parts of the delay lines. Those were however pivotal moments in the piece (beginning, midway re-entrance, dry signal strings, closure) sketched as axes, waypoints to orientate through the compositional structure. I would be most certain that an analyst could probably identify a dozen more passages verging towards a categorization of such function. However, one needs to underline that in gestures wherein the ensemble is producing output outside those parameters, the desired outcome was one of conflict and dissonance as stated previously. In any case, the functionality and appearance of scoring material within the dramaturgy can be comprehended by and through their relation to those displayed on the ‘table of spectral materials’ document, as they are pivoting from and are always comparative to them, either as interlinked copies- by sharing enough common pitch elements- or as simulacra- being outside the pitch territory- as well as during the motional relationships formed at the space in-between those signifiers” (Appendix C)

There is something very striking in Aggelos’s analysis (the paragraph above). Despite the fact that we both composed this work, I would never have been able to unpick this level of harmonic detail. My understanding of the piece is very different to Aggelos’s. Simply put, there is a lot about this work that I do not understand. This detail was encapsulated in the score and tacitly approved by me as myself and

Aggelos worked on the piece together, but as an artefact, it exists as a container of information that I helped to create, but would not be able to describe in any significant level of detail with a lot of effort. Similarly, Aggelos has a different understanding of the code to me. There was sometimes a palpable sense of concern throughout composition; despite the fact that Aggelos trusted me well enough to work with me, there were times that seemed anxious that the code would not work. I believe that this is because it was an element that was outside of his (direct) control.

We can identify a strand of dissimulation here. When, to each other, we described how we were working on the piece, we instinctively masked the more complex processes. Aggelos dumbed down the score when describing it to me, and I shielded Aggelos from certain complexities of the code when I described it to him. This abstraction process had material traces: the interface that I produced for this work was rendered to obscure the technical features beneath the visual interface. While this is a process that I would typically go through with any software design, I performed this visual abstraction much earlier than I would have ordinarily, because it was vital that myself and Aggelos were able to have meaning conversations about the code - *as something that we could both see*. On the other hand, Aggelos's dizzying knowledge of score production, orchestration and contemporary music harmony was neatly encapsulated into scores which I mostly didn't read - I responded to these elements of the piece as MIDI files and audio renders (things that I could easily work with). His harmonic technique became encapsulated in a format of the work that was simple enough for me to parse and work on. Despite the concurrency of these working processes, when I listen back to our premier's recording, the form of the work clearly has a coherent and *singular* identity. While listening, I am not interested in how this musical work abstracts two working processes, but how the different musical materials of the piece interact with each other to produce the temporal form of the work.

conclusion

Although people approach music in extremely different ways, it is easy to form a consensus around what constitutes a single musical work. As stated, Aggelos was primarily responsible for producing the score for our ensemble work, and I took more responsibility for developing the code for live electronics. The sounding form of the work emerged from these interactions between two compositional practices. While simply 'technological' feedback loops operated as part of its design, the 'social' recirculation of musical ideas and sonic form provides a much richer means of understanding the work as a feedback system. This system provided a basis through which we were both able to cultivate our specific working processes and channel them into the behaviour of a specific and singular piece; musical meanings formed from this our relationship as friends and colleagues, translated into perceptible sound events by the specific ways in which we each use music technology (MaxMSP for me; score generation tools for Aggelos; loudspeakers for us both).

As the recording of Assimilation / Dissimulation proves, music has little to do with outright consensus. The musical behaviours that emerged from the piece were defined by our ability to package up and express our working procedures to each other as we let the piece take form - at first manifest through spontaneous and often dead-ended improvisational bursts of musical activity, accompanied by alcohol, cigarettes and the provisional chat/banter that springs up when two people get to know each other better and become close friends. The sounding result of this social process is a clear and tightly defined container for some extremely specific musical functions, which playfully modulate the posited distinction of 'score' and 'code' as differentiated compositional labours. While the argumentation of this chapter required me to 'divvy up' the work into a two person job, the sounding form of our piece is more than capable of speaking for itself on an individuated basis. This social framing is helpful as we look towards the next chapter, where we can identify a much more complicated network of aestheticised social relationships.

chapter 04: how are social relations embedded into music systems?

Assembly Lines, the portfolio component that this project supports, is an audiovisual piece that I made with the Plus Minus ensemble's Vicky Wright on bass clarinet, Mark Knoop on piano and Aisha Orazbayeva on violin. For practical reasons (social isolation), I wanted to make a piece that explored the social aesthetics (a term that will be unpacked in greater detail) of the COVID-19 pandemic. The research question of this chapter - how are social relations embedded into music systems? - is an exploration of this idea. How do social relationships - and the way in which they mediate musical aesthetics - exist as part of music systems? All related practice can be found in [jackWalker_practice/chapter-04](#) (Click [here](#) for the Google Drive link).

In section 01, I discuss how this piece was made. Given that a primary aesthetic objective of this piece was to explore social relationships, I contextualise this work within the broader field of participatory art, with particular focus on participatory practices that have a strong focus on sound. In section 02, I discuss the system of social relationships that was used to produce this piece. In section 03, I pull back to the primary focus of this chapter - 'social relations' and provide a detailed account of how this piece relates to participatory arts and music practice more generally.

If the chapter before this - on 'feedback loops' - was concerned with the musical behaviours afforded by wildly recirculating communications apparatus, this chapter - on 'social relations' - adds loops upon loops upon loops, by channelling dynamic musical behaviours through broader, and more diffuse, social networks.

section 01: 'assembly lines' (2020)

You can find the work here (chapter-04/01_assemblyLines). Please watch before you move on.

description of 'Assembly Lines'

This piece was produced in socially isolated conditions by myself and three members of the PlusMinus ensemble. The form of the work resulted from 31 improvisations that were performed and filmed by myself and the ensemble, and then edited into fifteen minutes. I was primarily interested in ways of producing a group improvisation that was moulded together from a set of solo recordings. Musical interactions between players were achieved via an improvisation game, wherein players has to perform while listening to a 'prompt soundfile, after reading a short list of instructions. Recordings that were carried out by ensemble members were then digitally altered by me and sent to the next player. The material of the piece slowly emerged from this structured approach to improvisation. Although the individual improvisations that formed the work were carried out on an individual basis, they were still result of social interactions. Whereas in ordinary group improvisation these interactions would take place in real time, in Assembly Lines they were carried out through digital media: through audiofiles, video conferencing chats, emails, .pdf's, and video. As a component of this thesis, I use the technologically diffused social format of the work as a way of enquiring about the ways in which social relationships are deliberately embedded into music systems. As this chapter will conclude, attempting to fully understand the specific way in which social relationships contribute to the flow of musical information is risky endeavour; the optics of relational aesthetics can balloon to such an extent that artistic critique begins to feel more like self-aggrandizing delusion rather than musical analysis. However, yet more dangerously, the total elision of these social factors leads to a musicking culture that projects no self-awareness of its position in society at large, and an outright repudiation of the social problems that it categorically reproduces.

participatory art

Given that this piece is in some way constituted by the specific social relationships that formed it - i.e. the relationships between myself and the ensemble - and has been composed as a specific way of engaging with the social limitations imposed by coronavirus, it felt pertinent to relate this work to other artistic experimentations with sound and social context. I first contextualise these 'participatory' sonic practices in relation to a broader set of theories around art and social context - the field of participatory art - and then give some examples of practice that are both participatory and sonic. I do this to make sure I don't veer too much away from workings involving sound and music. For an examination of these participatory and sonic arts practices see Visda Gourdarzi, Artemis Gioti, Giacomo Lepri and Fabio Mor-

reale (2016). Their paper has a focus on the way in which the participatory experience is predicated by a need for feedback - stating that audience members could be credited as co-designers in future iterations of the project. "Unlike "relational aesthetics", our intention is not to assess art practices based on the social context they mediate, but rather use this social context as a starting point in order to transform the socialities between creators and audiences and potentially the art practices themselves" (2017, 01)

To look at a case study of a practice that can fit into this context, Benny Nemer's (Nemer, n.d.a) 'I Don't Know Where Paradise Is' "is a multi-chaptered audio guide that mediates encounters with the libraries and homes of a group of loosely-interconnected gay scholars and artists in Amsterdam, Montreal, London, Paris, and Vienna....Each chapter takes as its starting point an object found in and around the libraries, building on the idea of objects as conductors of feeling. These included a feather duster, a urinal, a house plant, a postcard of a still life, two clocks, and a shelf of biographies, among other items". The guide itself is installed via a mobile phone application, developed by Nikita Gaidakov, that presents a random selection of chapters, read by Ramsay and "Adeniyi Adelakun, Adrian Rifkin, Alberta Whittle, Oskar Kirk Hansen, Tomi Paasonen, and Will Stringer" [-Nemer (n.d.a); quotations because I copied the list verbatim from Nemer's website]. This work was presented in September 2019 at the Playfair Library in the University of Edinburgh's Old College. While the sound playback of the app was a fairly deterministic system, the way in which the sound responded to the environment was much more complex. The sound that emerged for each participant resulted from the recordings that were made; the way in which sound was processed between the editing stage and playback via the smartphone app; the random selection of chapters performed by the app; the particular type of headphone that the participant was using to listen; and the sounds produced by the participants themselves, all superimposed onto the auditory scene already present in the exhibition environment.

Socially, this act of listening was privatised in one sense, in that we knew (from Benny's introductory guidance) that we were listening to random selections of the text; it was clear that people were starting the experience at different times. Although we were all listening to the space thing, and all participating in the shared construction of the work (from Davis's perspective of listening equals making, see above), our perceptions were temporally disjunct from each other. We were participating in the shared and collective construction of something that was contingently localised to our private technology (our smartphone). The complex relationality of Benny's piece came up as a core theme of his chapters' text. His introduction notes that many things within his chosen libraries were resistant to documentation, and cannot "take archivable form. The spit on your face, the phone number written inside a matchbook, the unuttered word, something that was burned, but don't despair: these gaps are a material made up of the bonds and barriers that span between us our ancestors and those that have yet to appear on the horizons....if you

listen carefully, if you tune in to these gaps, something emerges. Listen. A vibration comes from the library. A hum” (Nemer, 2019). As noted, the listeners of the work were invited to hum at various points of the work: the audience invited to audibly signpost their acts of listening to the text. Moreover, the emergent social experience of the work impacted the ways in which participants would socially interact, leading to social behaviours that refer to cultural activities beyond the plane one locality of the work: “Guests commented on how the audio guide, the exhibition, and the number of bodies in the space choreographed movement in specific ways. People noted certain poses, pathways, gestures that the exhibition produced in bodies. One guest commented that he found himself actively cruising other participants, something that the exhibition awakened, permitted, or otherwise fostered in him” (Nemer, n.d.b, p. 179).

section 02: a network of social interactions

To map back to the primary question of this chapter - how are social relations embedded into music systems - we can see this piece as a study into a specific materialisation of social relationship. The social conditions of this piece were set before COVID-19 - I began composing the work while based in Austria, meaning I could not interact socially with the musicians in an 'ordinary' face-to-face fashion. This pre-empted the social conditions that were then set into place by the pandemic - the piece needed to be composable without face-to-face meetings. I decided to leverage this necessity for *physical* social isolation as a specific way of forming material for the piece. I wanted to see how the musical form of the work could emerge uniquely from these conditions. The specific music system that I generated to compose the work was grounded by these social factors: as the next section will show, the design of my system was based around these specific social limitations. This provides some simple basis for understanding how social relations are embedded into music systems. While composing the piece, I had a clear understanding about how these social interactions would be carried out on an abstract level - I knew that we would be communicating via email, soundfiles and videos, but I did not know the specific musical shape that would eventually be revealed. When seen at this abstract level, the social conditions imposed by COVID were structurally embedded into the piece that I composed. While the text above provides a useful historical and conceptual focus for my work, it does little to describe how these materials were actually formed as a system.

how the piece was made

Phase one: pre-pandemic (but still distanced)

I started composing this piece in late 2019, while I was working in Austria. Originally, the composers were asked to prepare some material to workshop with the ensemble at a session in Edinburgh. As flying back would have been impractical, I decided to design a music-based improvisation game that the ensemble could play without my actual presence. I improvised freely (I.e. I did not have any intention in my mind before starting to play) using my guitar and Tom Mudd's gutter synthesis ([see here](#); Mudd (2019)). This resulted in around an hour of sound material that I made selections from and edited into three short musical pieces. These sounds were then sent to the ensemble, alongside a recording of my voice in which I introduce myself and explain the rules of the game. The musicians were asked to do three things. 1) listen to the sound. 2) have a conversation about the sound and decide, as a group, how to respond to it, and 3) perform the response. There were no time limitations placed on each of the ensemble's improvised responses, and I did not specify for them to respond to the material in a particular way: I was more interested in hearing how they could collectively produce some music that was, in some way, a conscious response to my own. I described this to them as a sort of practical feed-

back loop, that went from me, to them, then back to me again. [For the materials and outcome of this workshop, please see here](#) (chapter_04/02_phase01_workshop).

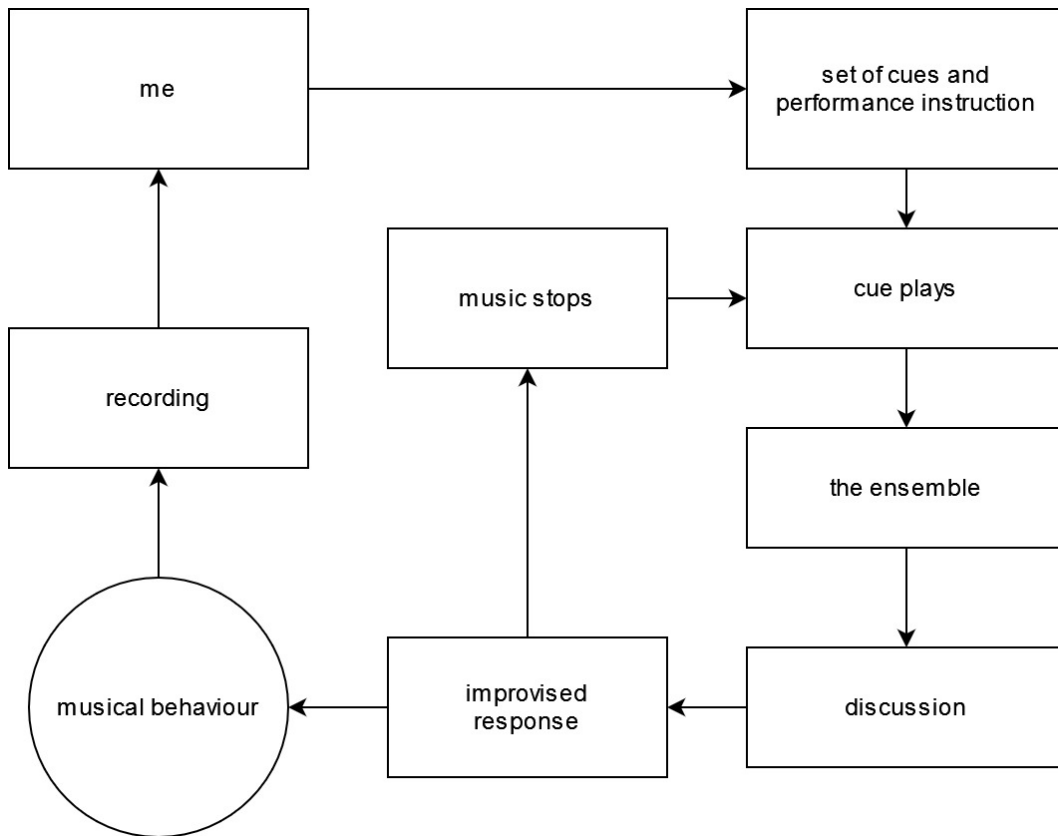


Figure 13: A diagram of how the Phase 01 system functioned

See [here](#) for a visual representation of how this Phase 01 process functioned as an improvisation system. Phase-01 workshop functioned as a system. The heuristic of this was fairly simple: I wanted to generate a recorded response from the ensemble, and did so by creating a series of cues and a recording of my voice that explains how the game functions. After my orientation speech, the ensemble would hear a cue played via the loudspeaker, discuss how to respond to it improvisationally, and finally perform this improvisation. This musical behaviour was recorded and sent to me. Seen in this way, the variety of the system was fairly limited. Either the loudspeaker is making a sound, the loudspeaker has just gone silent indicating that the ensemble should start their discussion, the ensemble are discussing what they heard, the ensemble are playing, or the ensemble has stopped meaning that a new cue can be played.

Phase two: an intentional response to social distancing

My initial plan was to analyse the material for particular kinds of playing behaviours, make some general rules about how to predictably encourage those behaviours, and then piece together three separate sounds, which each member of the ensemble would listen to and respond to in performance, but I had to change my plans to ac-

commodate the social distancing mandated by the 2020 coronavirus outbreak. As we were now required to work in a distanced manner, I decided to alter my plans, and make a piece of music by inviting each member of the ensemble to improvise over some small sets of audio recordings. I started with three of these sound-cues. Cue 01 was a recording of myself playing guitar, in way where I was really trying to exaggerate particular features that tend to crop up when I improvise. I also featured a recording of myself improvising with Tom Mudd's gutter synthesis patch. Finally, I included a recording of the workshops discussed above. I asked Mark to respond first, then Vickie, then Aisha. When each member of the ensemble recorded themselves playing over the prompt, I overdubbed the response onto the cue itself, meaning that each cue increased in complexity as it was passed through the chain. Alongside each cue, I featured some text that explained how I would like them to respond to the sound that I had created.

[Examples of this process can be found here]<https://drive.google.com/drive/folders/1OQAOahWnm9> (chapter-04/03_promptsAndResponses). In the first folder, '01_promptForMark' shows a starting prompt given to mark, followed by mark's response '02_responseFromMarkAndCueForVickie' (overdubbed onto the prompt). This was then sent to Vickie, and her response was overdubbed onto her prompt (03_responseFromVickie). In the second folder, a similar sequence is shown, but the responses are not overdubbed onto the starting prompts. Finally, '03_promptsAndResponses_total' is a screen recording of the total set of prompts and responses, to show the amount of different files that were generated through this process.

See [here](#) for a visual representation of this system. Here, we start to see a more complex network of organised social interaction. I send information to the players, which they interpret into music. They then send this music back to me, and I use it to generate new prompts for the players. By positioning the Phase-01 recording sessions in their larger social context, we can see how fit into a larger set of social interactions. Moreover, information was shared between myself and the players that was not rendered musically: scheduling information, notes about how to format audio files, etc. I have represented this above by showing two paths of communication between myself and the players. This is distinct from the musically focused loop established by the systems primary heuristic (see below), but is a supportive element of the recording sessions. To identify this heuristically, this set of operations was intended to produce a set of soundfiles from multiple iterations of the encapsulated musical game (i.e. Phase-02 recording sessions) that this phase is based around. When each game is completed, the sound that resulted from the session is overdubbed onto the next sound then sent on to the next player. Sound example: this layering behaviour can be heard in 'section_02::02_phase02_cue' and '03_phase02_response'. The first sound, Mark's response to my first cue (heard in section 01), was used as a cue for Vickie, who overdubbed her response.

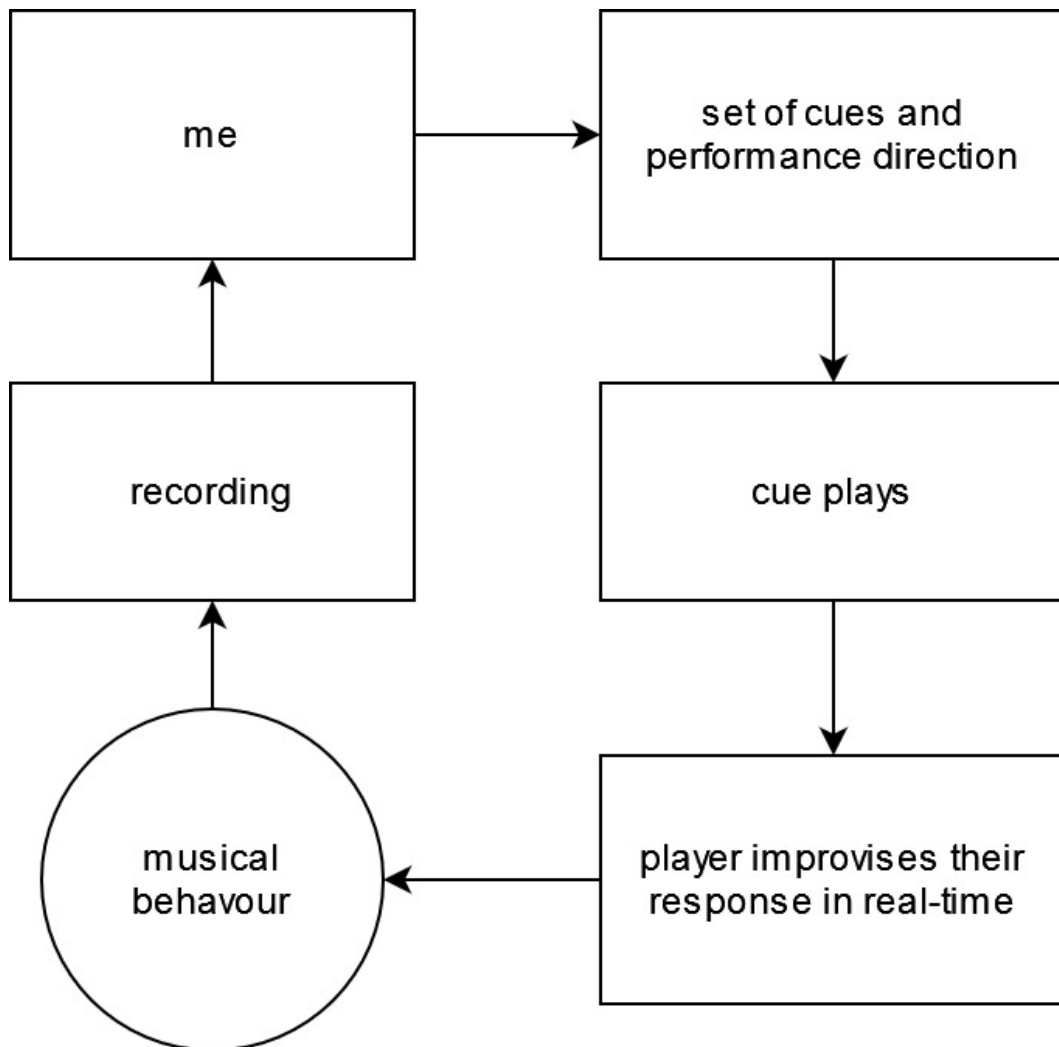


Figure 14: A diagram of how the Phase 02 system functioned

Phase three: in studio

In phase three, I went through the responses and edited a piece together. My approach to doing this was mostly intuitive – I wanted to be fairly free of restriction and form higher-level materials together based on quick and hacky engagements with the various forms that can be pulled together. An edit eventually emerged and was live-streamed as part of an Edinburgh College of Art master's show. I supported the edited piece with electronic sounds in a very low maintenance fashion: I experimented with different types of sound processing continuously as I listened back to the ensembles responses, eventually deciding to use FFT freezing effect ([see here](#)), delay lines, corpus-based concatenative synthesis([see here](#)), pitch shifting and saturation, alongside EQ, compression, reverb and subtler degrees of saturation as I mixed the various recording into a single structure. As a general but loosely maintained rule, different types of electronic sound processing were foregrounded at different points of the piece. I begin with FFT, move slowly towards delay lines, start to incorporate FFT again, before we hear a pitchshifted bass clarinet solo, at which point all electronic sound dies off.

The piece was presented visually, with the players visible through small rectangles presented onscreen. I wanted to provide some representation of electronic sound, so visualized a rendered sub-mix of electronic material using a spectrum analyser that is bundled into DMG Audio's Dualism. At the point the electronic sounds died, the sounds from the ensemble start to trickle into the spectrum analyser; a visual narrative which is intended to hint towards the electronic nature with which the ensemble were articulated as sound. This is possibly a question of ownership. Throughout most of the piece, there is a clear distinction between 'my' electronic sounds and their 'instrumental' recordings, given that we can see the way that their sounds result from their interactions and, if the relationship between electronic sound and the visualisation is noticed, we can see that my sounds trace their way down the screen as colours. This distinction is blurred as the ensemble clearly become responsible for provoking a response.

section 03: social relations as abstractions

The specific ‘abstraction’ that this chapter focuses on is: social interaction. This piece was produced by attempting to produce an abstract link between two different ways of socialising: the in-the-moment encounters of live group improvisation (MacDonald & Wilson, 2020) and the set of solo improvisations that I recorded for this project. This piece was made out of ‘social interactions’. First, the material for the piece was specified by communications between myself and the players, either carried out via videoconferencing chats, emails or the .pdf documents that I sent to them. This relationship between myself and the players provided the core systemic basis through which the chain of communication was fleshed out into sound. Second, the players interacted with each other by hearing and responding to sounds that were produced by the players. Third, the final form of the piece renders some communication between the different players.

Although they were not playing synchronously (i.e. literally playing at the same time), the sound that is produced is presented as if it is, with all streams of audio playing simultaneously. The identities of the players as rendered on the screen respond to the sound of each other in a virtually rendered fashion, achieved via the perception of the person watching the video. Although they are not literally playing together, it isn’t difficult to imagine that they are. In this latter case, the social interactions that constitute the piece are rendered in the imagination of the viewer. Finally, in order to present the work as a live-streamed performance, I was required to interact with the people who were running the event, so that the work could be presented to an audience. An abstracted view of this final part of the process can also be seen as an interaction from myself to the audience. The audience also communicated back with me, via discussions with people that I had about the work. My understanding of what was a ‘social interaction’ while composing this piece is something that is general enough to cover each of these different types of communication.

social relations as music system components

To begin to sketch out a potential relationship between my systems based composition and broader approaches to basing artworks around social interactions, we can look towards Tom Davis’s synthesis of Waters’ performance ecosystem (Waters, 2007) with Nicholas Bourriaud’s (Bourriaud, 2008) relational aesthetics. Relational aesthetics is a theory of contemporary art practice that claims that the material of certain artworks is a collectively developed social interaction: the aesthetic substance of relational art operating at the interstice between those in attendance, with all participants helping to produce this shared experience. Tom Davis’s (Davis, 2011) synthesis of relational aesthetics and the performance ecosystem formalises “an understanding of the performance (ecosystem)’s relationship to relational aesthetics...draws a link between the social aspects of music-making, the idea that art is created from social exchanges and the site of music creation as a special place for

the process of collective aesthetic production” (Davis, 2011, 124). Primary motivations for Davis’s study to seem to be a) to draw attention to the productive capacity of subjective perception: in both performance ecosystems and relational artworks, artists and audience members are productive components of the work, and b) to laud these participatory and relational practices as a tool for engendering change in the world: “(a)rt not only changes our perception of our surroundings but also alters the subject, engendering change within ourselves: it recognises that, although we change through our observations of the world, in observing the world we also change it” (124). What is left unexplored, however, is what this change will be.

‘If relational art produces human relations, then the next logical question to ask is what types of relations are being produced, for whom, and why?’ (Bishop, 2004, p. 65) (Bishop 2004, 65). While Bishop claims Bourriaud’s theory to be ‘an important first step in identifying recent tendencies in contemporary art’ (53), she is left wondering why Bourriaud neglects to query the actual relationships that the work draws into being. Bourriaud argues that the production of relational art is a politically useful act in itself, through its negation of passive art consumption and its production of utopian society (i.e. manifesting “societal perfection” (69) on a microcosmic scale: “the interactivity of relational art is...superior to optical contemplation of an object, which is assumed to be passive and disengaged, because the work of art is a “social form” capable of producing positive human relationships. As a consequence, the work is automatically political in implication and emancipatory in effect (62)“. However, she wonders why relational artworks so often forge connections between people who already know each other:“(t)here is debate and dialogue in a Tiravanija cooking piece, to be sure, but there is no inherent friction since the situation is what Bourriaud calls “microtopian”: it produces a community whose members identify with each other, because they have something in common” (67), this pre-existing conviviality occluding the tension and chaotic disagreement that you are likely to encounter in ‘real life’. She concludes a more radically relational art aesthetic would explicate, not elide, these pre-existing social antagonisms: “(t)his relational antagonism would be predicated not on social harmony, but on exposing that which is repressed in sustaining the semblance of this harmony. It would thereby provide a more concrete and polemical grounds for rethinking our relationship to the world and to one other” (79).

Georgina Born (2010; 2017) agrees with Bishop that Bourriaud’s theory obscures the specific details the social relations that his championed artworks bring into being, but focuses her critique on his lack of specificity around his definition of ‘social’. “Crucially, (Bourriaud) seems here to be arguing that relational art both participates or partakes in wider social relations and that it stages a microsocial space apart that may refract or ‘distort’ them” (Born 2017, 35), thereby failing to “fully to theorize this crucial point; he has no vocabulary to distinguish between the several modalities of the social that he conflates” (35) To more fully describe these frames, she considers the social context of an artwork as operating on four planes. First, plane

one, the work is part of the immediate social and spatiotemporal context of its performance (i.e. the physical location and timespan of a gig or exhibition). Second, plane two, art produces ‘imagined communities’: virtual groupings of people that are created by shared aesthetic orientations (i.e. bands of musicians, fan groups, scenes, art worlds). Third, plane three, art reproduces pre-existing social relations (i.e. race, class, gender, sexuality, authority, nationality). Fourth, plane four, art is inextricably woven throughout wider and more powerful mechanisms of human cultural behaviour (i.e. capitalism, nation states, academia, arts institutions, globalisation). Each of these planes affords a specific context through which can critique the relational quality of an artwork, allowing us a more specific set of metrics that we can apply to determine how art aesthetics are constituted by social relationships. As this paper will demonstrate, both Bishop’s (2004) and Born’s (2010; 2017) critiques of relational aesthetics can be attached to Tom Davis’s initial synthesis, in order to produce a more detailed examination of the connections between Waters’ (2007) and Bourriaud’s (1998) theories.

watching the piece in 2022

When watching this piece back, I wonder whether I should interacted more. I was so keen to give everyone their say that I forgot what I wanted to make with the piece. The five short structures contain interesting musical materials, but as a single presentation, they Luckily (I think?), the institutional and cultural contexts had not finished attaching aesthetic meaning to the piece. The Microsoft teams version of the piece collapsed the stereo information to mono. The mix was initially carried out over headphones, and the separation between the sounds produced by the violinist and clarinet player relied too heavily on this spatial character. When reduced to mono, it sounded fuzzy and undefined. Moreover, the specific codec used to compress the audio for livestreaming reduced the quality of the sound. As Aggelos Masantonis stated (he also had a piece played at this concert), the piece sounded like it had been run through a cheap chorus effect. It seemed distasteful. While this was disappointing, this does indicate an entry point for specific social aesthetics As my brother pointed out when I went to see him after the concert (I was originally planning on playing the piece to my siblings but I felt too oversaturated with what I had seen of the piece in the Microsoft Teams version). However, while this does open up the idea that the aesthetic of the piece was socially mediated, Does the fact that my work is social make my work social in the same way as other ‘relational artworks?’

Davis’s arguments (2011) could allow one to describe my work as intrinsically political: the way in which subjectivities are drawn together into the collective expression of an aesthetic unity engenders the productive capacities of the audience-turned-artists; the participants given the abilities to express themselves and kindly freed from the abject horror of passive spectatorial consumption (Bishop, 2012). This is of course political in the Skunk Anansian sense (“Yes it’s fucking political; everything’s political”; track 03, 1996), but what actual change does it cause? To a large extent,

we cannot know. It is impossible to anticipate the particular ways that the piece will interact with the world in future. However, as seen before, we do have some reliable methods for determining the extent to which an artwork connects itself to the social world around it. As Bishop states (2004), the political utility of a relational artwork is delimited by specific social relationality of the work. As Born states (2010; 2017), the social relationality of the work is further complicated by the work's interaction with and complicity within four planar scalings of social context. These four planes are: the real-time social context of performance (plane one); the groupings that musical experience forces us to recognise, bands/scenes/etc (plane two), pre-existing descriptions of identity, including race, class, sexuality and gender (plane three) and the institutional contexts that are channeled by the work (plane four). As should be clear, claiming that my work was political in the same sense as Benny Nemer's would be fallacious as anything other than a broad and abstract comment on art's political potential. The specific ways in which each work can act politically are mediated by the specific arrangements of social environment (Born's four planes) that shimmy the work into being. When we invoke a more reliable set of metrics for examining what these environments are made of, we are forced to encounter the 'in-real-life' social contexts that occur around the work.

With IRL social contexts come IRL social responsibilities. My piece, as an academically presented example of electronic music (it's plane 01 manifestation took place at an Edinburgh College of Art concert), fits comfortably into the wider (plane four) social context of electronic music research. Social problems in electronic music - in turn refracting social problems in music technology, academia and culture - are easily identified. Lauren Hayes and Adnan Marquez-Borbon (2020) point towards a political crisis in music technology research: a contemporary desire for academies and conferences to foreground the importance of diversity and inclusion in their policy statements, while doing little to counter the sociopolitical landscape that leads to a monocultural research environment. Annie Goh and Marie Thompson (2021, 127) elucidate the lack of women and non-binary people represented in contemporary discourses on sound and technology, motivating their theory of 'sonic cyberfeminisms' as "both a conceptual tool and an organising rubric for a series of events and projects that interrogate the relationship between gender, feminist praxis, sound and technology" to redress and work creatively with this imbalance. Amble Skuse and Shelly Knotts (2020, 01) demonstrate that music technology is invented for and marketed towards non-disabled people, meaning that acts of technologised musical expression are often siloed to people who fit the normative criteria of 'non-disabled': "(u)nless this playing field is levelled, the voices of those with spare time and energy to contribute tend to be heard over the voices of those who do not". When querying the sociopolitical relationality of performance ecosystem-type works, and the theories that spring up around them, we might not want to ignore the problems that are within arm's reach. If ecological and relational arts practice provides a reliable way of altering the world around us, then we can identify a long list of specific changes

that we might want to make. From this we can see the danger of over-abstracting the social context of music systems.

conclusion

As a semi-improvised piece of music for multiple improvisers, the social relationship between myself and the ensemble was, to me, the key and most interesting determiner of musical behaviour. Paradoxically, my work as a 'solo artist' - working in quite literal isolation - provided the ultimate form of the work as expressed as an (uncompressed) audio file. Moreover, to note another paradox, the eventual form of the work as produced in concert was dictated by conditions imposed by live streaming. Clearly, this piece was mediated by multiple different framings of social relation and their specific social values that are aesthetically encoded into musical work. However, as has been made clear, too much fixation on this connection between art and social life can lead people to attach unrealistic claims to their practice. Broad polemics on the social or political viability of participatory practice are rhetorically useful but easy to criticise. If artists and theorists are interested in examining the productive capacities of relational art and music, as something that engenders change in the world outside of immediate aesthetic experience, then they may want to examine the specific social changes that were brought about by the piece. My favourite moments of the piece are the places where it seems like I am not intervening at all and just letting things take place.

However, it is clear to me that the work could have benefitted from a more considered approach to structuring the materials: I was so enamoured with the things that came out of the rehearsal that I attempted to find a place for all of them. The specific social interactions that came from the piece were so entrancing that I tried to document as much of them as I could, rather than honing in on a tighter framing of a self-assured musical structure. However, it is satisfying to note that the end result of this process channels the behaviour of COVID as an aesthetic influence. The sounding result of the piece is certainly representative of this specific time of my life: the edit was rushed, anxious and chaotic, and hampered by my lack of video editing software (this process did at least make me realise just how dependant I was on Edinburgh University as a provider of media development tools, a fact that I have since rectified by getting my own stuff together). Further, the fact that the audio was disgracefully compressed and presented over *Microsoft fucking Teams* is reflective of COVID's working culture (as is the expletive I used when describing Teams; I didn't really have a strong opinion on it before): poor quality audio heard by pissed off people staring at their laptops. The role of tech in this social mediation of music is explored in a deeper (and sunnier) manner in the next chapter, as I start to think about how machines can be programmed to augment - rather than caricature - our working musical values.

chapter 05: can I treat a software patch like a person?

This chapter supports ‘Egregores’, a set of seven short pieces for humans and computer. These works were composed while I was artist-in-residence with the Institute for Electronic Music’s Inter_Agency project (IEM, n.d.), with Manuel Alcaraz Clemente and Margarethe Maierhofer-Lischka of Graz’s Schallfeld ensemble (Schallfeld Ensemble, 2021). My original plan for this project was to design a live performance piece for ensemble and computer. The methodological foundation of my proposal was the idea that machines can be implemented in performance as things that act like they are making musical decisions. The primary research question of this chapter - can I treat a MaxMSP patch like a human? - encapsulates this goal. Given that I compose works for human beings who I invited improvise, it was intriguing to question whether I could treat computers in a similar way. All related practice can be found in jackWalker_practice/chapter-05 (Click [here](#) for the Google Drive link).

In section 01, I discuss the background of this piece, I put this work into a broader practical context by referring other practitioners/theorists who explore the relationships between human and machines in composition. In section 02, I run through the construction of the piece, which (similar to the previous chapter) is based around three phases: in ‘phase 01’ I attempted to implement and document the simplest possible musical interface that felt like it was capable of making musical decisions, in ‘phase 02’ I rehearsed and workshopped the piece with the players, resulting in a corpus of sound recordings made at this stage; in ‘phase 03’, I composed and EP comprised of six short pieces of fixed media music. In section 03, I draw back to the primary theme of this chapter - ‘ethics’ - as I focus on how musical working processes can translate into a material that is abstract enough to be communicated to machines.

If the preceding chapter - on ‘social relations’ - discussed music as something that is, invariably, mediated by social context, this chapter - on ‘ethics’ - adds a technological component to this mediation: ethical values about music described as things that can be embedded in machines.

section 01: 'egregores' (2020-2022)

You can find the work here ([chapter-05/01_egregores_EP](#)). Please listen to the contained sound files in order before you move on (or while you read if you are pushed for time).

description of 'egregores'

This is a set of pieces that I made with Manuel Alcaraz Clemente and Margarethe Maierhofer-Lischka of the Schallfeld ensemble. The form of the EP is a series of edited and processed excerpts from a set of rehearsals for a piece that was sadly never performed live in concert. The initial aim of the piece was to feature live gutter synthesis ([see here](#); Mudd (2019)), corpus-based concatenation ([see](#)) and delay lines performed by a live computer agent. The human members of the ensemble were to improvise alongside this system. The musical aims of the piece were to a) find a set of semi-improvised playing behaviours ('human presets') that we could collectively agree upon as an ensemble, b) produce a set of electronic sound materials ('computer presets') that we could agree were supportive of the musical features of the human presents, and c) follow a loose script for improvisation wherein the humans and computer agent must switch between attempting to mimic or counterpoint the sound produced by other ensemble member (the computer understood as a member of this ensemble). Sadly, this never happened. However, there was a considerable amount of material from these rehearsal sessions that I liked and wanted to make into new works of music. I edited these pieces into 'Egregores', a twenty-seven minute EP of short works for human and computer. While this musical outcome is extremely different to what I had planned (and, honestly, I would have much rather continued to work with Manu and Maggie on a live concert work), this EP is still a worthwhile contribution to my investigation into live music systems. While there is no longer any live computer agent responsible for structuring the electronic sound materials in real time, I turned the project into an exercise for better understanding *why* I would want such a system to exist in the first place. The primary conclusion of this slightly tangled study - that my working sensibility as a composer is something that can be embedded into the tools that I work with - answers the title of this chapter with a caveat. Yes, we can treat software agents as if they are humans, and delegate performance responsibilities to them as such. However, if we are to like how these things behave, we can look at ourselves rather than at technology. Musical desires are perhaps best understood as something that stem from perceptual relationships with sound, rather than the outcome of technological process.

Inter_Agency

These works were composed while I was artist-in-residence with the Inter_Agency At the Institute for Electronic Music ([IEM, n.d.](#)). The primary aims of IEM's In-

ter_Agency research project are to investigate the motivation for “human-computer symbiosis in electro-instrumental music” (IEM, n.d.) and to develop upon practical approaches to implementing interactive and ‘intelligent’ systems when applied to experimental ‘electro-instrumental’ music. To put this work into practical context, I will discuss a piece that was composed for the Inter_Agency project. Gioti’s Imitation Game, a piece for human and robot, is:

“an interactive composition for human and robotic percussionist, incorporating machine learning and musical robotics. The composition is based on a dynamic form, shaped by decisions made by the musician and the robotic percussionist in real-time. The robotic percussionist interacts with the human based on machine listening, particularly a Neural Network trained to recognize different instruments (cymbals, bongos and cowbells) and playing techniques (strokes, scraping and bowing), while the musician interprets a non-linear score which enables him/her to adapt to the robotic percussionist’s actions in real-time.”

Gioti’s desire to see a human improvising alongside a computer is supported by a broader context of such approaches. George Lewis’s *Voyager* (Lewis, 1987) features an autonomous music system that listens to improvising co-performers and behaves as if it is capable of improvising itself. Martin Parker’s (Parker, 2013) *GruntCount* is an example of work in which a software engine moves between different types of live electronic sound applied to the instrument of a human improviser. This is to produce the effect of a machine improvising with a human. Moreover, Rebecca Fiebrink’s *Wekinator* (Fiebrink, 2017), while not a musical work in itself, has been used as a readily available approach to using machine learning tools as an interface for music making. Similarly, the *FluCoMa* (FluCoMa, n.d.) project encapsulates a range of approaches to this idea, working as a set of tools for working with machine learning in MaxMSP, PureData, and SuperCollider programming languages, with works composed by Alice Eldridge, Sam Pluta (Pluta, 2021), etc. The technological entities that constitute these music systems (pieces of software or hardware that perform a specific interactive function within the context of the system) can act as though they have some musical agency that is separate to that of the system’s composer (Di Scipio, 2003; Gioti, 2020, 2021; McCormack et al., 2020).

To put this work into a theoretical context, Gifford et al (2020) provide one robust approach to critiquing the extent of agency that is exhibited by a computer music system with their concept of ‘creative agency’. Their understanding of the agency that is demonstrated by music systems rests upon whether the human being can understand the system “as contributing to the ongoing creative collaborative activity with some degree of autonomy” (ibid,p.1) potentially from “emergent, complex dynamics within the system’s design, or...algorithms designed to instill autonomous behavior into the system.” (pp. 2-3). Their study reveals a spectrum of approaches to achieving this, spanning from those featuring “heavy use of hard-coded rules of musical structure and/or preprogrammed sequences” (p. 13), and freer systems that “impose little stylistic constraints on the performer, but rely on human listening as

the primary aesthetic evaluation method” (ibid). From this, we can begin to trace different ways in which composers can embed their own compositional preferences, stylistic tropes and musical desires onto machines. Systems from the ‘hard-coded’ end of the spectrum will potentially assume that their human counterparts will be able to understand and respond sensibly to the particular stylistic idioms and tropes that are embedded into the software (presumably mapped according to the composer’s personal tastes), while the latter may adapt more fluidly to the environment into which it is deployed, allowing the human player to project their own musical preferences onto the machine with less real-time resistance.

As evidenced, we can identify a variety of practical and theoretical explorations of this notion of machine agency in composition. When applying to be artist-in-residence for the Inter_Agency project, I used my proposal to set out the specific way in which I wanted to work with this idea. If we accept the presupposition that machines can make musical decisions in real time - as the compositional practices and theoretical approaches to music and artificial intelligence state we can - how can ensure that we like the things that they do? In my proposed contribution to Inter_Agency, I wanted to explore this particular question. I understood this as a task of embedding my compositional work ethic (here defined as the set of things that I musically value and want to see reflected in performance) into a machine. Through the process of designing music systems that are capable of behaving with some degree of autonomy, by acting as if they are making decisions about musical structure in real time, composers embed something of themselves into the technology that they work with. In a sense, they are communicating musical working values to a machine, in a manner similar to how live musicians might be verbally directed before a semi-improvised performance: they generate a language that we can use that, when sensibly unpacked by the other party, can be translated into a desirable musical experience.

AI and work ethics

“What is most startling about the history of twentieth-century sounds is not how much recording technology has changed music, but how little it has” (Frith, 1996, p. 246).

I never got as far as this in my own research with Inter_Agency. This could lead one to question why I am structuring this chapter around live music and artificial intelligence, given that the primary musical outcomes are clearly fixed media works that were made in studio, carried out without any significant AI component. This lack of a concert premiere was certainly unplanned; as will be explained further down, the project had to mutate into something that could be finished off from home, due to circumstances that were out of my control. To answer this, I refer to the preceding quote of Simon Frith. This claim, quoted from a broader polemic on the complicity of music technology in wider industrial forces (Frith, 1996; resonating deeply with recent claims of Georgina Born 2021, below), provides a useful conceptual overlay

for the relationship between AI and this work. There are many good practical reasons to fixate on the possibilities of AI/ML in music practice (Gioti, 2020, 2021), and the generative impact that these technologies could have upon musicking culture (Fiebrink, 2017). However, I worry that such tools are often deployed in a manner similar to Leigh Landy's notion of "technology for technology's sake" (Landy, 2021). This fetishization of technicity (Green, 2008), to restate a primary refrain of this research, often forces an elision of historical, cultural and social factors (Hayes & Marquez-Borbon, 2020; Waters, 2007).

While there is nothing wrong with musical works that are primarily created to evidence a technological proof-of-concept (e.g. practices demonstrating that novel technologies can have musical utility), technology can be integrated in a deeper manner, as something that correlates with musical, rather than technological, conceptions of value. However, while a worthy enough starting off point, my polemic here does very little to state *what these values actually are*. I take a slightly backwards approach to answering this question in the following section. I begin with an evaluation of three small-scale engagements with sound and crude automated systems. I then discuss a process of workshopping a piece for live electronics and ensemble performance, which was originally intended to feature a significant AI component. I finish with an examination of how I constructed the Egregores EP, and how this tracks to the types of musical behaviours that I want my technology to make. This latches onto broader questions of AI – how are these systems mobilized in cultural production and how do we want them to behave (Born, 2021; Crawford & Joler, 2018; Walker, 2019, 2020, 2021a, 2021b). To finally draw back to Frith (albeit a more positive spin than his broader critique of music technology in late capitalism), we do not know the types of music practice that AI will foster down the line, but I strongly suspect that the most striking aesthetic outcomes will latch onto something deeper and more limbicly ancient than any technological framing of how music can be formed: musical value generated by perception rather than technique.

three studies of agency and ethical value

agency studies

“The presence of a feedback loop, even a rather simple one, constitutes for us humans a strong pressure to shift levels of description from the goalless level of mechanics (in which *forces* make things move) to the goal-oriented level of cybernetics (in which, to put it very bluntly, *desires* make things move). The latter is, as I have stressed, nothing but a more efficient rewording of the former; nonetheless, with systems that possess increasingly subtle and sophisticated types of feedback loops, that shorthand’s efficiency becomes well-nigh irresistible. And eventually, not only does teleological language become indispensable, but we cease to realize that there could be any other perspective. At that point, it is locked into our worldview” (Hofstadter, 2007, p. 54) (54, strange loop).

To find the prototypical improvisations discussed in this section, please see here (chapter-05/02_phase01-agencyStudies).

At the beginning of this project, I produced three short improvised pieces in a small amount of time. In designing these pieces, I gave myself the challenge of trying to produce the lowest level of machine listening system that I could imagine. I tried to solve this problem by theorising upon two simple low-level ways in which a machine listening system can receive, interpret and alter the way in which sound is produced: envelope following and event detection. I wanted to see how easily I could pull together complex forms of music that are based on extrapolations from these two simple principles. `as_01.wav` is a recording of a system made up of two microphones, two envelope followers and two loudspeakers. I play the piece by changing the gain applied to the microphones and moving my hands against the mikes. See [here](#) for a diagram of this performance system.

`as_02.wav` is a recording of a system made up of two microphones, two envelope followers, a gutter synthesis patch and two loudspeakers. I play the piece by changing the gain applied to the microphones and moving my hands against the mikes. As I do this, I try to match the sound that I hear from the loudspeakers by changing parameters of the synthesis patch using mouse and keyboard. See [here](#) for a diagram of this performance system.

`as_03.wav` is a recording of a system made up of two microphones, two envelope followers, a simple corpus-based concatenation patch ([see](#)) and two loudspeakers. I play the piece by changing the gain applied to the microphones and moving my hands against the mikes. As sound enters the microphone, is mapped to the concat patch, which attempts to replicate the input sound by drawing from its corpus (made up of samples of myself playing guitar). See [here](#) for a diagram of this performance system.

With a tiny amount of coding, a laptop connected to an audio interface, two microphones and a loudspeaker, I was able to use my body as a way of exploring the sonic

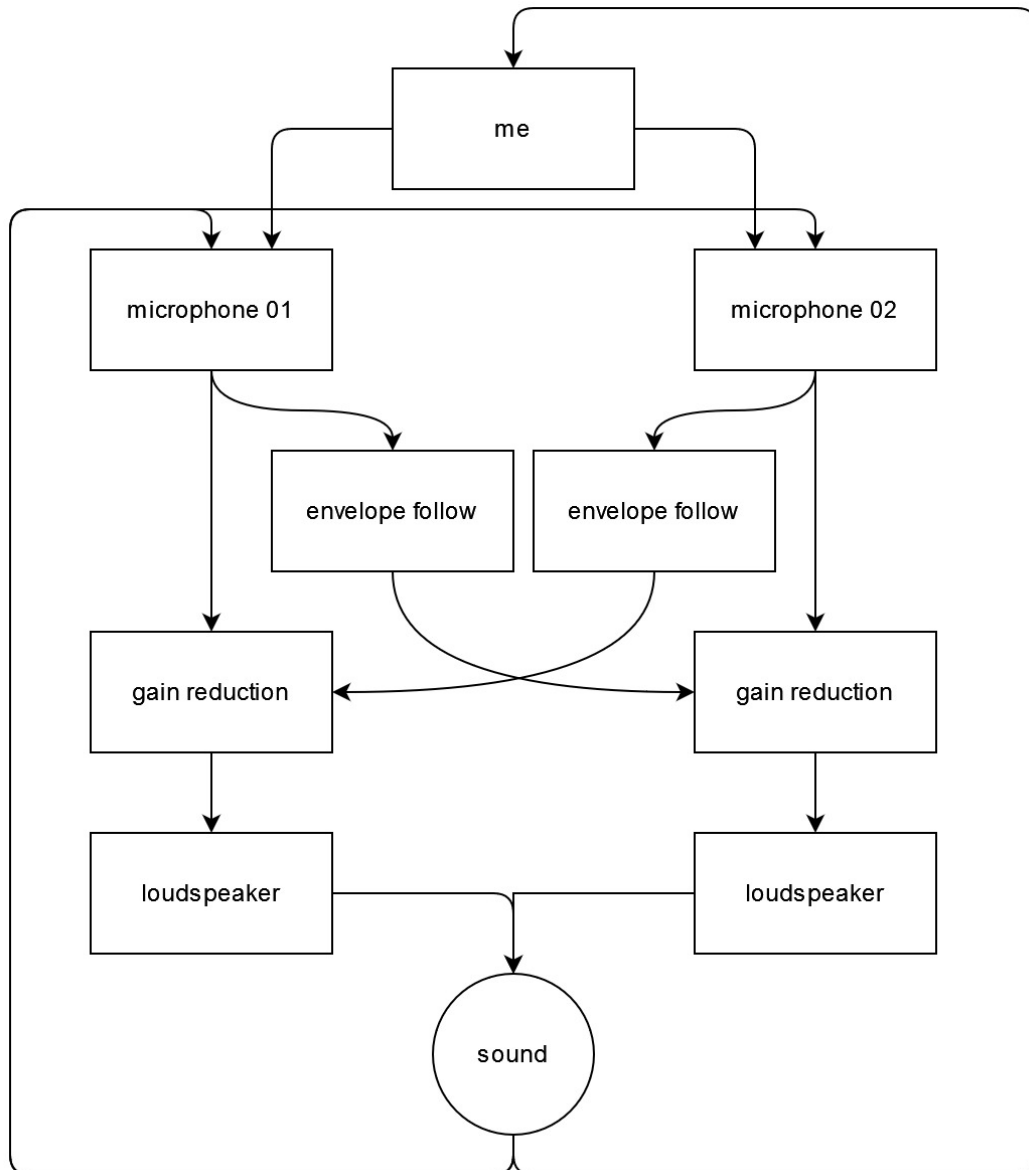


Figure 15: Agency study 01: feedback loop with envelope follow

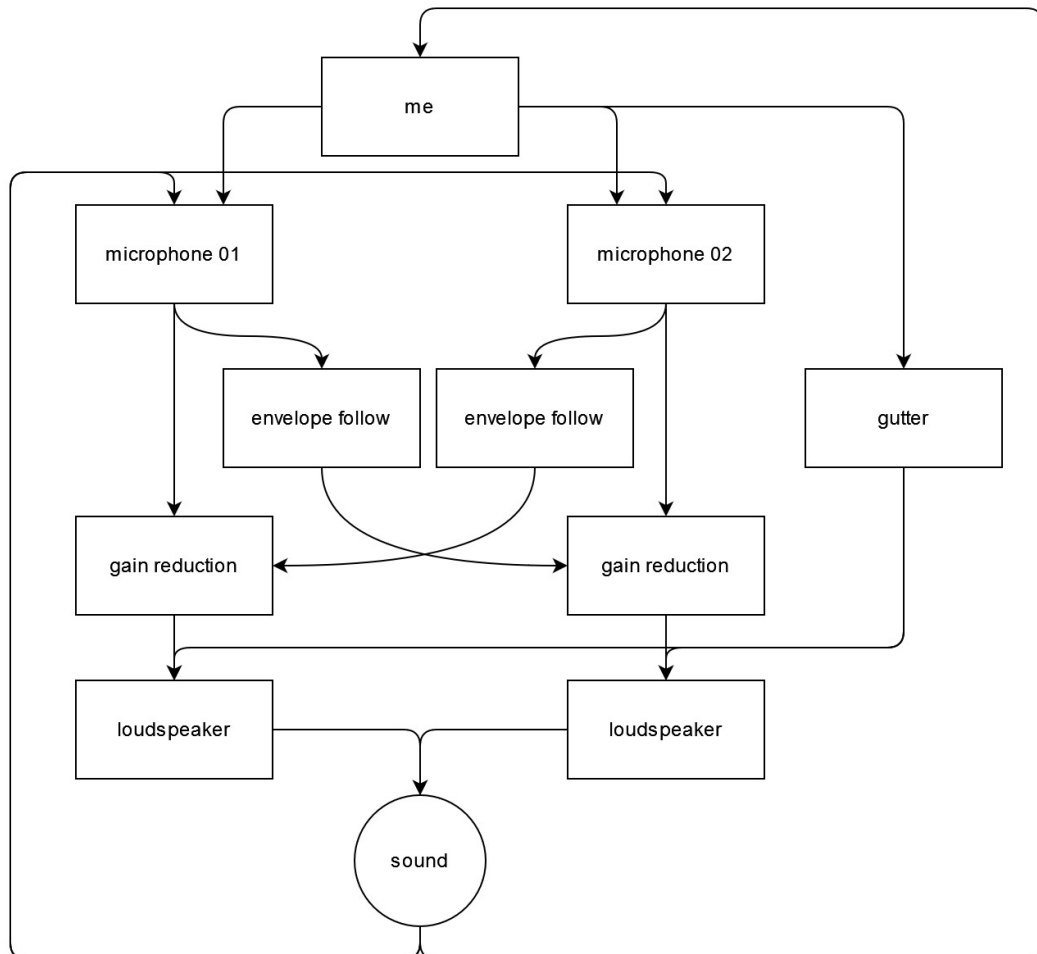


Figure 16: Agency study 03: feedback loop with envelope follow and gutter synth

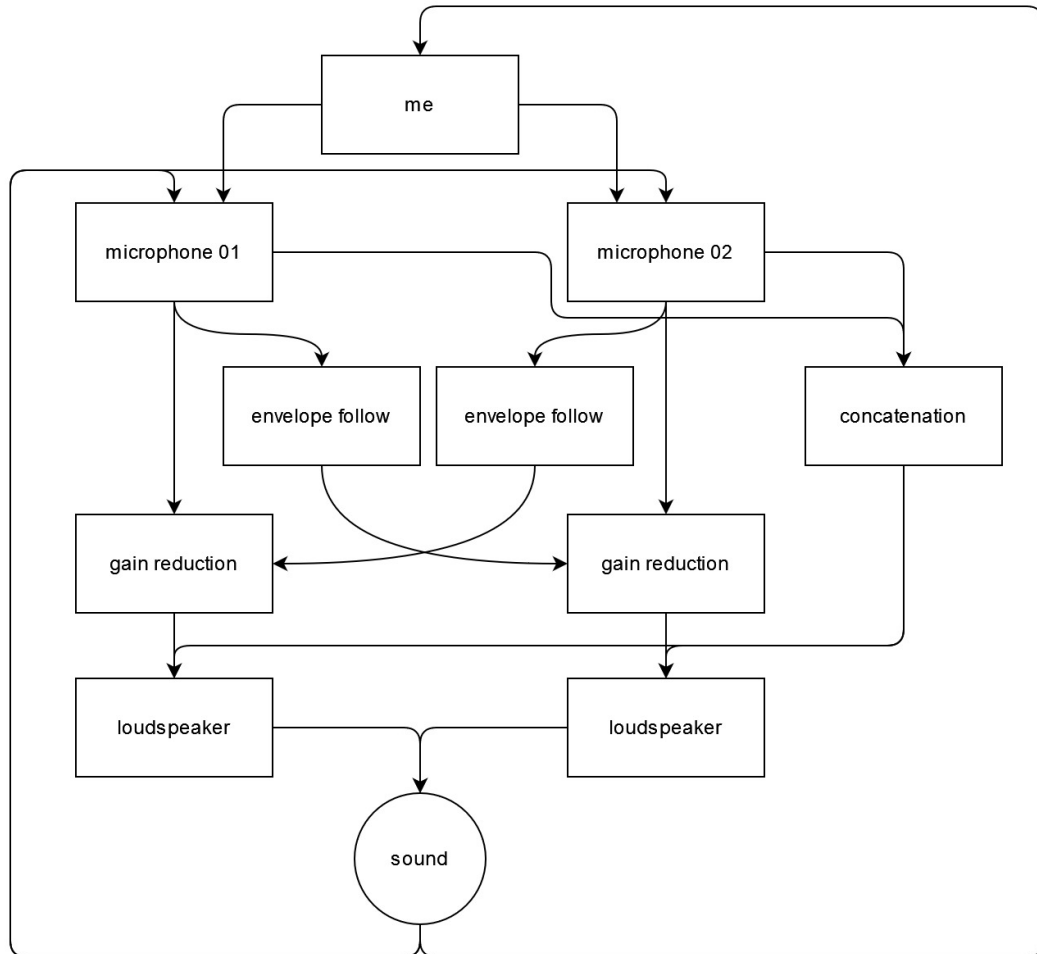


Figure 17: Agency study 02: feedback loop with envelope follow and concatenative synth

possibilities afforded by these simple computer interfaces. This tiny infrastructure was easily integrated with existing music systems. First, I played my feedback instrument while interacting with Tom Mudd's gutter patch (see [here](#); Mudd (2019)). For this improvisation, I set myself the challenge of using my ears to track the pitch of the emergent Larsen tone, so that I could attempt to match the parameters of the gutter interface to encourage a harmonic relationship between the two sound sources. The sounds from the gutter were fed back into the microphone and reinforced the 'gutter-like' qualities to the Larsen Tone generator. Second, I loaded up an audio-driven corpus-based concatenative synthesizer (see Tremblay & Schwarz, 2010), pilfered and quickly adapted from the MUBU MaxMSP documentation (IR-CAM, n.d.). This system extracted sets of real time sound descriptions from a sum of my microphone inputs and searched through its corpus of sounds to find a short snippet of sound with the most similar descriptor profile to the most recently evaluated input dataset. Again, this produced complex self-reinforcing behaviours, as sounds from my corpus (which was filled with samples of myself improvising on guitar) could be heard by my microphones, meaning the concatenation system would fall into brief patterns of responding to its own output. Neither of these systems were labour intensive from a coding perspective: it was possible for me to vastly increase the technological complexity of my system with very little additional code.

rehearsals

I recorded four multitracked rehearsals with Manu and Maggie, resulting in around 20 hours of raw audio data. In each rehearsal, we discussed the types of sound that we were interested in and then experimented with some short semi-directed improvisations. In these mini explorations, I would invite the player to use a particular playing technique (i.e. a specific preparation for Maggie's bass or a particular set of percussion for Manu's set), or to move between a few different sound behaviours.

solo rehearsals

During my first rehearsal with each player individually, we had two primary aims: to decide on what we would physically bring with us to the performance. In my case, this was a set of microphones, a laptop computer, and software. In their case, it was their instruments and preparations. In my initial talks with Maggie, I was keen to stress that I saw the process as a collaboration: she knows her instrument and her improvisational style much better than me, and I would rather tap into her own understanding of how she would ordinarily produce sound, rather than forcing a particular aesthetic criteria on her from the outset. My compositional role in this setting was to establish commonality between sounds that she liked and sounds that I liked, and communicate my feelings to her in a way that allowed these desirable sounds to be easily reproducible. This was typically achieved by attaching quite weak but 'catchy' semantic descriptions to the sounds that I heard (droney, scrapey, harsh), which was surprisingly effective for allowing us to understand that we were

both talking about the same thing. The basic framework for this rehearsal was a process of listening to players experiment, listening to what they said about what they performed, while observing their body language and tone of voice to sense their interest in the material.

The materials were selected as follows:

Maggie: [superbows](#) (chapter-05/04_phase02_rehearsals/superbow) (small plastic eggs attached to nail files and used to agitate resonant objects), a large polystyrene cone that can be placed between strings in order to modify their resonance, a head massager that could be placed against the strings and caused the strings to resonate in a different way, and some wooden beaters.

Manu: a low tom, a spring coil taken from a tractor engine, a snare, a set of three cymbals – one cymbal duplicated so that one could be covered in foil and the other left unprepared, and a Tibetan singing bowl. These items were to be played with a superbow, a range of wooden sticks, a whisk, a bow, a superbow (see above) and an electric toothbrush with the brush removed.

tutti rehearsals

In our group rehearsals (which the musicians would refer to as ‘tutti rehearsals’), my aims were roughly as before, but slightly more complex due to the increase in technical complexity. 1) I wanted to get a sense of how everything would be miked, fed into my system and used alongside sound processing, 2) I wanted to further refine the overall range of material that we had access to through performance (i.e. preparations for Maggie, drums and preparations for Manu, and specific sound processors for myself). 3) I wanted to identify particular types of sound events that we were capable of collectively producing, in order to begin to understand how we could reliably talk about particular playing styles in such a way that they could be easily reproducible by the group. After each short improv, we discussed the music and how we felt about it. We quickly established several ‘modes’ of making predictable improvised sound (i.e. ‘fast modes’; ‘tonal modes’; ‘modes with multiphonics’; ‘modes with groove’; modes where the players mimic/counterpoint each other’). [See here for two sound examples](#) (chapter-05/03_phase02_presets): one in which players stay in a single mode, and one in which players move between two modes through time. From these specific methods of improvising sound, we devised a shortlist of modes that we felt worked well together. If I directed the players to one of these modes, I was largely able to predict the sounds that I would hear. This gave us a shared and abstract language for communicating about how we could structure the piece. (Please see here for recordings of these sessions.) Throughout this process, I was keen to stress the fact that there would be a machine performing along with them.

[Please see this directory for sounds, images and videos that document this process.](#)

to performance!

My next challenge was to refine a set of synthesis parameter presets that I felt were sonically alike to these modes of playing, so that every modes could be reliably achieved by the humans and the computer. I devised a system for switching between preset states in accordance with sound description data taken in and classified by Wekinator (Fiebrink, 2017) – a tool that can be used to trained to classify multiple different types of sound behaviour. I then began to work with the players from the Schallfeld ensemble. I approached this by conceptualizing my piece's 'score' as a set of abstract instructions that govern how the humans and computer could musically behave. Equivalence in messaging was key here: I wanted to feel like I was using the same vocabulary to direct both parties. A simple example of this can be found in the word 'listen'. While the process of 'listening' to sound will be different depending on whether you are a biological organism or a robot, we can use the term 'machine listening' to understand what happens when a computer extracts sound information from a real-time audio input. If I understand 'listening' as an umbrella referent for both biological and machine listening, then I can find a single abstract instruction that can meaningfully address both humans and machines. The tension in the piece would then arise when Wekinator classified input data 'incorrectly' (a term that I use with a caveat – any misclassifications were likely to be my error in training Wekinator, rather than a mistake made by the machine). This would encourage moments where the electronics and the ensemble would contradict each other, resulting in a more chaotic order of events. The players could then sustain this tension or fall back into easy beds of sound that the machine would have less difficulty classifying to retrieve a sense of unity and cohesion (see Bowers & Green, 2018; Green, 2013) for discussion of how 'errors' in machine listening algorithms can produce musically interesting results).

...and back into the studio

Sadly, my piece was never finished and performed in concert due to the Covid-pandemic. While this was quite disappointing (although starkly trivial in face of the pandemic's global impact), on closer inspection it gave me an opportunity to interrogate my musical intention with an air of sobriety not easily afforded by the chaotic (mis)management of coding, rehearsals, caffeine and anxiety that usually accompanies the final stages of a work of my concert music. With the small amount of time that I had to finish the piece (roughly two weeks) suddenly expanded to the length of a global health crisis, I had the opportunity to slow down and evaluate the material that was recorded from the rehearsals. I decided to make an EP from the material that we gathered, by editing together various excerpts from the rehearsal sessions, and processing them in a DAW. I saw this as a distillation of a process that I have gone through multiple times when working on pieces for other people (notably, for the context of this PhD, *Assimilation / Dissimulation and Assembly Lines*). When in the intermediary stage between rehearsal and final performance,

I would typically assemble sounds that I had recorded from the rehearsals in a DAW or MaxMSP patch, so that I can experiment with processing the sound and sketching out rudimentary structures, to see how different sounds fit together. At this point, I would be thinking through the relationship between sound processing and the live electronics interface. For this project, I was keen to continue this type of thinking, because I didn't want to drift too far from the notion that the source material was initially produced live on a semi-improvised basis. It would have been possible for me to transform the sound materials to such an extent that most listeners would not be able to determine that they had originated from live ensemble performance (e.g. with very fine granulation or extreme FFT processing ([see here](#))), but I did not want to obscure the efforts of Manu and Maggie. This latter point helps set out how I am doing research with these materials: although the research outcome has shifted from a live performance to a set of fixed media pieces, I still see this project as investigation of human and machine agency in live musical performance (a point that I will address in the next section).

The primary difference between finishing this EP and taking a prototypical piece to performance is that I did not have to perform the things that I made to other people. Although I produced multiple interfaces for implementing live processing, these artefacts did not need to be robust enough to produce interesting sound consistently through a live performance. This is an extremely different design challenge. The task of making computer music interfaces bug free, readily performable and portable enough to survive an arbitrary range of performance spaces is well documented in new music studies [([Tremblay, 2017](#)). It is significantly more problematic than studio work, where the system is, ideally, contained within in a space that is carefully designed to provide consistent musical experiences to a small number of listeners. Moreover, the range of processes that can be engaged with in a studio is expanded by the forensic and iterative nature of studio practice: the musical experiences are typically contextualised by the project at hand, and therefore adhere to different working standards. In public performance, it would seem strange to play the same song fifteen times in a row, but repeated listening is an essential component of careful mastering work ([Katz, 2007](#)).

Without needing to produce a tool that could withstand live public performance, I was able to take a hackier approach to interface design. Sound playback was achieved via MaxMSP and REAPER, with sound routed between the two programs using ReaRoute. MIDI data was sent from Max to REAPER using LoopMIDI. Sound description was achieved in MaxMSP, using the FluCoMa and MUBU packages. Sound processing was achieved via proprietary plugins in Reaper (reverb, EQ, filters, impulse responses, modulation FX, delay, saturation, pitchshifting, compression), with parameters addressed via MIDI control messages from MaxMSP, envelope automation in REAPER, and a hardware MIDI fader bank. Core musical behaviours included: automated FFT freezing ([see here](#)) triggered by attack detection; amplitude envelope following within REAPER to modulate FX parameters;

gestural control over parameters with mouse, keyboard and the MIDI faders; timestretching in REAPER; concatenation in MaxMSP. This process was carried out in a fairly chaotic and hacky way, as I was concerned with testing a lot of ideas very quickly, with a minimum of coding. I enjoyed getting lost in this process, as this helped me to feel that the musical outcomes were emerging from this complex assemblage of different techniques; balancing my desire to foreground the musical decision making that can be heard in the rehearsal recordings with the excitement of creating new sounds that would not have been possible without the ability to go back and forth over the material. [To get a sense of this hackiness, please see here](#) (chapter-05/05_phase-03_hackyAutomation) for a video.

section 03: 'ethics as abstractions'

To contextualise this project as a continuation of my study into machine decision making, there are three correlations that we can identify. First, from a *conceptual* perspective, the early designs of this piece, and the way it was articulated to the players, always featured some computational method of making musical decisions. The specific way that we formed materials throughout the rehearsal process was inflected with the idea that a machine would be taking part in this performance. I was keen to refer the players to the types of sound that the live computer would be making, and the ways in which it would change through time, so the players were constantly modulating their performance with reference to this ghostly artificial intelligence. The set of materials that I had to work with were already polluted with this sense of machine autonomy. On a more concrete and *technical* basis, while composing these works in studio, I implemented some crude forms of machine listening and automation into my workflow, to give my computer some ability to flesh out or refine material on an autonomous basis. To this end, I looked back towards the very start of this project (see>>>), and generated some very simple tools for envelope following and event detection. However, my use of these tools was cosmetic rather than structural (i.e. I was very much 'in the loop', and able to dispense with machine decisions when I did not like them), and I would never try and claim that my piece featured the sophisticated human-machine behaviours that one could observe in Voyager (Lewis, 1987), GruntCount (Parker, 2013) or Imitation Game (Gioti, 2018). However, I will still firmly contextualise this work as a study into machine agency. On a *perceptual* basis, I was making value judgements about sound and then embedding these choices into a machine (i.e. by arranging items in REAPER's arrange window or recording in MIDI automation using a set of faders), so that I would be likely to hear desirable musical material when I instructed the computer to play it back. This process - the act of instructing a computer to generate desirable musical experiences - is the most significant part of embedding a musical work ethic into a machine.

The final point of the previous section is intended to be slightly provocative. Of course, I could not argue that the end point of this project could be presented as serious research into artificial intelligence, as there is no significant technical exploration of this subject. However, it is still a valuable engagement with the idea that computers are capable of making musical decisions for us and the aesthetic considerations of this type of music practice. In 2021, I presented a paper (Walker, 2021a) at the Artificial Intelligence and Musical Creativity (AIMC) conference that evaluated the first two phases of my project with IEM (i.e. the initial prototyping and the rehearsals). I came to the conclusion that, when we do ask computers to behave autonomously, we have to devise strategies to ensure that we like the things that they do. This is, in my rhetoric, a process of embedding machines with a sense of 'ethics': the ability to make value judgements that are commensurate with our own. This requires our ethics to be communicable to computers, meaning that they must

be abstractable to a quantity that can be unpacked by humans and machines. As a 'musically generative abstraction', the materials for this chapter were developed around this goal, and the musical practice has better informed the types of things that I need in place in order to streamline interface design for live or studio practice. My 'hacky' experiments (i.e. the tools developed in phase 01 and phase 03), were following a blunderbuss approach to assessing my needs for the piece. This is a total contrast to the interface that I designed for *Assimilation / Dissimulation*. However, it should be clear that there were behaviours carried out by myself that could be implemented via the automated responsive processes familiar to the more sophisticated AI-inflected live music systems. This suggests that the rudimentary tools devised to instil my pieces with music that I liked should be abstractable enough to have a life outside of this project. Clearly, tools that I have developed at this stage could be valuable components of more complex AI systems. Part of developing a clear method for instilling machines with a work ethic lies in the ability to translate processes that are carried out in experimentation into devices that could be implemented by machines.

ethics as music system components

This chapter also rubs up against another type of ethics, one which is less focused on immediate musical experience: the ethics of artificial intelligence as a developing cultural presence. Kate Crawford and Vladan Joler's 'Anatomy of an AI system' (Crawford & Joler, 2018, p. 2) sum up these issues with remarkable (if daunting) clarity:

"With each interaction, Alexa is training to hear better, to interpret more precisely, to trigger actions that map to the user's commands more accurately, and to build a more complete model of their preferences, habits and desires. What is required to make this possible? Put simply: each small moment of convenience – be it answering a question, turning on a light, or playing a song – requires a vast planetary network, fueled by the extraction of non-renewable materials, labor, and data. The scale of resources required is many magnitudes greater than the energy and labor it would take a human to operate a household appliance or flick a switch. A full accounting for these costs is almost impossible, but it is increasingly important that we grasp the scale and scope if we are to understand and govern the technical infrastructures that thread through our lives".

We can put these ideas into a musical context:

"So this is the challenge, and the experiment. So, what would this mean for artistic practices? What kinds of challenge are thrown up once the AI music community reframes the boundaries of its activities and brings what are now deemed to be the environmental and social externalities generated by AI into view, as fully part of the system - part of its responsibilities?"

Georgina Born's words, from her keynote presentation at AIMC 2021 (Born, 2021),

raise a deeper connection between artificial intelligence and ethics. Foreshadowed by an evaluation of Kate Crawford and Vladan Joler's (2018) *Anatomy of an AI system* – a harrowing overview of the planetary social and environment impacts of Amazon's 'Echo' AI system, her question frames the broader implications of AI as something that can be addressed through music practice. This posits the idea that music practitioners who use AI are connected to a more general set of problems. While the ethics that I have discussed so far are local to my own compositional practice (aesthetic or social values that I wish to see reflected in the music that I make), Born's provocation suggests that, in using AI in any musical capacity, I should be adherent to an additional set of ethics: values that I hold regarding the state of AI as a more pernicious – or outright destructive – cultural presence.

I don't have a clear answer to this problem. It doesn't seem like something that could be addressed through singular creative action, but seems more likely that her 'call to arms' is to generate a culture around AI in music that is aware of the devastating potential inherent to automated systems technology; these latter impacts of AI seemingly emerging from the values of capital rather than the values of musicians. Moreover, I believe that musicians hold the ability to generate their own relationship to such technology as it continues to develop in sophistication. We do not know the types of music practice that will emerge from conferences such as these decades down the line, but I agree with Born that we should be careful to recognize the destructive traces of the technologies that we see musical value in. I believe that this is a matter of developing tools to reflect the types of value that we wish to encounter in the world around us. This, in a very small scale and idiosyncratic way, was the thinking behind my approach to structuring this project.

listening to this piece in 2022 (post-composition)

Listening back to this set of pieces, and the specific ways in which I have a) selected sound materials to foreground from my set of recordings, b) edited these fragments of sound into pieces, c) selected live digital signal processors to apply to these materials, and d) modified the parameters of these processors through time, provides me with a set of value judgements that I can make about the things that I like to do as a composer. Crucially, they provide information about how I want people and computers to interact. If the sound behaviours encoded in my EP are representative of the ways in which I want sound to exist, how can these ideas be taught to machines in future? Broadly speaking, this is a process of experimentation with the process of allowing machines some ability to make these decisions. Although this was a crude approach to instilling value systems onto computers, the musical materials that were created through this process are indicative of the types of things that I wanted to work with musically. These ideas are useful musically because they help to set the scene for the possibilities of music technologies that project this idea that they are able to convey our musical ethics. They raise questions that can be asked about the role that computers play in performance. When agency is deferred to a

machine, what kind of musical behaviours do we expect of them?

“After Crawford and Joler, we can never frame the Amazon Echo - but also the entirety of the infrastructure supporting AI - in the same way. For these environmental, social and cultural costs have to be reconceived, and re-empracticed(sp), as occluded elements in the system - elements that can't be framed out as mere externalities, but must be embraced in our thinking, and, I suggest, in your artistic and musical practices. So this is the challenge, and the experiment. So what would this mean for artistic practices? What kinds of challenge are thrown up once the AI music community reframes the boundaries of its activities and brings what are now deemed to be the environmental and social externalities generated by AI into view, as fully part of the system - part of its responsibilities?” (Born, 2021)

Although this project only sketched out a formative engagement with AI and autonomous systems as a component of creative music practice, there is a clear relationship between the idea of embedding one's compositional value systems into a machine, and the notion of producing a music technology that is reflective of broader values that we hold. I don't have a clear answer to Born's proposition that musicians must find a way of reframing the social and environmental complexities of AI. I think this is the type of question that only further practice can rigorously engage with. To look at this project from a rhetorical rather than musical standpoint, I share Kate Crawford's concerns that AI systems typically reflect the values of their designers or funders, rather than the values of those whose lives they will occupy (2018). If understanding is the basis of empathy, perhaps we can encourage a standpoint that clearly frames empathy as human *and* computational value. I worry that artificial intelligence technologies primarily suit the values of capital rather than the values of those who the technology will impact most. I share Crawford's concern that the social impacts of artificial intelligence are often overlooked, and that critical thinking is imperative if we are to properly assess the impacts of integrating autonomous systems into state and commercial infrastructure; think critically about the way in which machines can interpret and respond to human ideas of value. The musical benefits will be immediate, and we practitioners can hope that good AI in music tracks to good AI in culture; a Christopher Small-ian performance ritual to propagate and foster our planetary agenda. At least if we die in the process, we get to jam with robots for a bit.

Conclusion

Although we can identify a lucrative tradition of using computers as things that can make decisions in live performance (or at least feel like they can), the reasons why we might want to do this are less clear. The EP of pieces that I composed for this chapter were produced as part of an investigation into the potential of machine learning and composition. As a collection of pieces, the form of the overall set emerged from a series of experiments and investigations in machine listening and live electronics. The musical materials that emerged from technical experimentation, improvisation,

code prototyping and group performance are all inflected with this search for a machine that could make musical decisions for me. The actual sonic form of the work, however, was for the most part technically achieved through the use recording techniques, sound processing approaches and DAW techniques that utilised very little machine learning or artificial intelligence. This was not initially the plan: this set of pieces was intended to be a single concert work for duo and live electronics. However, the specific steps that I took to composing this inadvertently fixed media set of pieces can still be evaluated as a document about how I want sound to exist as something that is done by machines. The primary motivator, both for this EP and the piece that I ideally wanted to make, was to identify abstract ways of understanding musical values as things that could be understood by human beings and by computers. The pieces were evaluated according to the way in which I encode computers with specific musical values. Processing operations were carried out in accordance with this idea and frameworks were generated for allowing machines to produce these behaviours in future. This understanding of the works latches onto the ethical implications for this understanding of value can help us to understand the role that music technology can play in the production of AI technology more generally.

This final point elucidates the primary thesis of my doctoral research: that my music practice is something that is produced by abstractions. The musical form of the EP material evidences some of the risks associated with the idea of understanding agency as something that is so abstract. If agency is something that can be felt rather than measured objectively, to what extent do we need to account for the agency of everything, as a totality, rather than the individual contributions of the human participants of the systems? The sound quality of the works of music was clearly not a result of computational decision making, but rather a process of talking about computers with human beings. The agency of the machines was present, as an abstract threat, but computers were rarely used. When they were used, they sometimes did not behave in ways that I wanted them to. However, present in the sound and in the computational processes that I used to organise the sound is an enormous amount of redundancy. The things that I was doing as a composer can be automated. This ability to automate sound behaviour does not solve the primary working problem though: how can I ensure that the computers do things that I like? This is a process of working with sound - and the sound quality of the work evidences tightly defined abstractions around how I want sound to exist as part of my compositional practice in future. This futurity connects to the conclusion of this thesis, where I will give a final run down of the findings of each chapter and set a concrete basis for understanding how my practice exists as an interactive music system.

conclusion

“It is the endlessly multifaceted intersection between different similarities and differences, which may join together, include one another, ignore one another, cancel one another, contradict one another, or silence one another. Which may be made present (or not) in the form of texts, inscriptions, bodies, skills, instruments, sensibilities, architectures, ghosts, spirits and angels – and all the other materialities one could imagine. Always, what is absent is a set of potential patterns that buzzes and dazzles and dances, that is too complicated to condense, to make present” (Law, 2004, pp. 116–117).

Tacitly or otherwise, composition is a process of identifying, organising and operating upon abstractions of musical form. A composer’s working practice is a system constituted by a specific framework of abstractions. As composers spend their lives constructing an understanding of how music can be made to exist, this system is populated with fresh material affordances: things that can be unpackaged as music in future. This happens through composition of specific musical works, each allowing their overarching container to absorb new data and produce new abstractions. This feedback loop of absorption, extraction and regurgitation is core to my own understanding of how music is processed by the dynamical behaviour of my consciousness. This music system - the perceptual and psychological mechanics that define my music practice as a totality (everything I have ever done and will do with music) - cannot be apprehended and used to squeeze music out like toothpaste. A top-down control surface is impossible. So, to approach from a manageable level, my thesis describes five works composed using five systems. If we take these five systems and identify what they have in common, we better understand how my practice operates as general structure. While not reaching the ‘consciousness level’ system described above, this process starts to illuminate a framing that overdetermines all five works of music. As we invite this construct to absorb each new piece and metabolise its contents, it happily swells and develops in sophistication. Throughout this final chapter, I expand on this idea and discuss five framings of my practice, before ending with a poetic account of how music is formed by listening, discrimination and generalisation: traversing a line between redundancy and risk.

five framings of my compositional practice

My compositional practice is populated by a set of abstract behaviours that span throughout my work. These abstractions are persistent through multiple understandings of what my musical practice is. This thesis described a process of identifying and implementing these ‘musically generative abstractions’ across a portfolio of composition work. my practice, rendered in this submission as my portfolio of composition, was developed over my lifetime of listening to, playing and talking about music. Paradoxically, it simultaneously operates at a much lower level of abstraction: as techniques that I perform in order to make sound appear acoustically in the context of a specific piece. Spanning these two poles - top-level material abstraction on one hand and low-level physical behaviour on the other - we can identify a practically infinite arrangement of different systems that I use to make music. These systems can be described as interactive states of sound, or *presets* (see Chapter 01); as networks of *clocks* (Chapter 02); as *feedback loops* (Chapter 03); as *social relationships* (Chapter 04); or as co-productive *ethical* relationship between human and machine (Chapter 05). Each of these five framings describes a different set of abstractions: lower-level than my ‘highest level’ music system, but higher level than mechanical sound behaviour. However, as each chapter demonstrates, no matter how I systemise a work of music, it will eventually need to collapse into reality as the perceptual experience of sound. As shown, exciting things happen at this final stage when I have a coherent understanding of what prior abstractions are needed for the specific musical experience at hand.

chapter 01: solo guitar as a software patch

Starting off, I discussed a semi-improvised piece that I composed for solo guitar. The structure of this piece was something that was largely predictable prior to performance (i.e. I had specified the *types* of musical material that I would encounter), but included an element of indeterminacy (i.e. the specific organisation of these types through time was not defined prior to performance). This piece was made as an investigation into ‘presets’ - a design component common to computer music interfaces. Despite not using computers, presets were still used a core specifier of musical form. This was partly to encourage overlap between my practice as a live improviser and my practice as a computer musician, and primarily to investigate the role that predictable ‘states’ play in my music system design practice.

chapter 02: TxH

Following this chapter, I discussed a fixed media piece of acousmatic music. Material for this piece was produced in collaboration with Tina Krekels, which was coupled with other materials (synthesised sound and improvised guitar) and arranged in a DAW. The specific arrangement of sounds was based upon the temporal organisation of a Bitcoin transaction, which was mapped out and used to direct the ways in

which different types of sound interacted through time. The collision between time as a factor in Bitcoin (i.e. the timeframe of a transaction) and time as encountered in music (i.e. the timeframes of perceptual experience) was used to further understand how 'clocks' - things that measure time - are implemented in music systems and used to direct the flow of sequential musical events.

chapter 03: Assimilation / Dissimulation (Mastrantonis and Walker, 2019)

I then discussed a work of concert music for ensemble and live electronics, composed by myself and Aggelos Mastrantonis. From one level of analysis, the musical form of this work resulted from the interactions between score and electronics: feedback loops stemming between these two primary framings of musical structure. These loops were enacted by myself and Aggelos throughout the composition of the piece - through improvisation, prototyping, rehearsal, concert and documentation - and formed the primary basis through which the piece was able to demonstrate its motility and exist as a unified and singular musical structure. This practical framing is used to extend and understanding of the different types of feedback loop that can be systemically exploited and provoked into music.

chapter 04: assembly lines

Here I discussed an audiovisual piece, edited from a set of semi-improvised recordings made by the Plus Minus ensemble. I sent the players a series of short, audible 'prompts' that the players would listen to while recording themselves improvising in their own home. Each prompt was supported by a short document that outlined suggested methods of responding to the material (dynamics, pitch, timbre, preparations, responsiveness, etc). Simply put, when a player returned a prompt to me, I then overdubbed their response onto the prompt and emailed this new prompt to the next player in the chain. With form emerging from this diffuse social interaction (comprising the prompts, any other chat with players, the prompts and the responses), I used this piece to interrogate ways that social relationships are built into systems and used to deliberately modulate musical behaviour.

chapter 05: egregores

Finally, I discuss an EP of pieces of fixed media music, made up of semi-improvised materials that I recorded with Manu Alcaraz-Clemente and Maggie Maierhofer-Lischka of Graz's Schallfeld Ensemble. Throughout this process of working on the EP, I implemented a variety of simple systems that were used to make decisions about sound input, so that the recorded sound generated by the players was able to impact the emergence of electronic material. While only a crude presentation of such technique, this work was used to unpack the notion that computers are able to make 'musical decisions' (or at least act as if they do), thus hinting towards the

prospect of an ethical outlook on sound that is abstract enough to be shared by both humans and machines.

a livelier interpretation of my primary argument

“(L)iving beings, having been shaped by evolution, have survival as their most fundamental, automatic, and built-in goal. To enhance the chances of its survival, any living being must be able to react flexibly to events that take place in its environment (most earthbound beings can pretty safely ignore comets crashing into Jupiter). Once the ability to sense external goings-on has developed, however, there ensues a curious side effect that will have vital and radical consequences. This is the fact that living being’s ability to sense certain aspects of its environment flips around and endows the being with the ability to sense certain aspects of *itself*” (Hofstadter, 2007, p. 73)

Valuable things happen when sound is transferred between different conceptualisations of what it is made of. Audible Larsen tones provide a useful example here: when sound is transmuted between an acoustical state into an electrical signal and then back again, the positive feedback loop is able to expand this connection between different instantiations of sound into a musical material: the form has life beyond its conception as ‘electrical’ or ‘acoustical’. Digital recording and playback offers another: acoustic sound translated by microphone to an analogue waveform then jaggedly encoded into discretised data. This new digital format is only partially representative of its continuously variable input (gaps between sample values are lost and reapproximated), yet can be reformed to provide a strong audible referent to the genesis acoustic sound. Machine listening provides a third example: sound is analysed according to features that can be related to the processes of hearing: values that we can ascertain and use to describe sounds can be translated into things that can be understood by machines. Every work in my portfolio draws from this (almost alchemical) process of seeing what happens when sound is described by plural conceptions of materiality, yet hinging these materialities to things that occur regardless of substance.

This latter claim draws me back to Georgina Born’s materiality of musical assemblages. Music being so materially diffuse - so subject to instrumental, temporal, situated, social and technological mediations - raises a significant problem about musical ‘work’. We can argue that some composers work by instantiating dynamical systems and reinforcing their positive behaviours, but what are these systems actually made out of? Purely technological answers to this question are, of course, reductive, failing to properly account for the social, cultural, temporal and environmental mediations of musical quality. However, a truly holistic account - the set of all conditions that overdetermine musical experience - is too complex to be usefully appended by design. As has been claimed repeatedly throughout this thesis, it is impossible to observe all factors that mediate the specific orientation of sound by performance. To interface with this ‘God’s eye view’ music system (the musical assemblage; Muray Schafer’s macrocosmic musical work (1993); Cage’s ‘everything’ (Kostelanetz, 2003)), we need to package it up into terms that we can grasp. The

total scope of musical potential needs to be harvested into something that can be operated practically by a human. The easiest way to do this is to listen.

I find an almost spiritual (i.e. strongly correlated to my core beliefs) value in Muray Schafer's macrocosmic musical form of the world (1993), but I find it extremely irritating as a practitioner. There is something rhetorically beautiful in the idea that all sound participates in a single and universalising musical work, but it is quite daunting practically. When mapped to my own understanding of listening as a constructive process, it accounts for one of my lowest-level convictions: that consciousness produces the reality we experience and that engaging with the world sets it into a productive and reciprocal motility. This relationality and interconnectedness of everything - our perceptual complicity in universal fabric - is a useful top-down rhetoric on participation in higher order expressions of reality (e.g. it imbricates us with forces that are too complex for us to recognise), but fundamentally useless to me when designing specific musical works. When all music occupies to the same frame of reference, it is impossible to discriminate any one musical event from another. Without the ability to parse, compare or criticise, music collapses into a fixed set of infinite sinusoidal humming: all frequencies, at equal amplitude, forever. If listening is the most graspable way to work on music, discrimination is the second. We cannot discern musical structure without an understanding that *things change*.

This, however, leads us back towards infinity. If any musical event can be distinguished from all other to precede it, we shift our focus from an infinitely sustained *synchronic* harmony, towards an infinite *diachronic* string of heterogony and contrast. We can certainly claim that any one musical event is perceptually distinct to any other: due to their psychological, physical and physiological make up, when given a single sound source all listeners will hear it slightly differently. Moreover, from a thermodynamical perspective, successive instances of this 'single' musical event will form with variance, due to the ceaseless environmental changing that occurs in the gaps between each instance (shifts in heat or dampness impacting each novel soundwave propagation). While this point is, again, rhetorically useful (to explicate the differences factored upon music by ecological contingency), this account is simply not commensurate to how human beings perceive music. Our base apprehensions of pulse or melody argue that things happening once are fated to reoccur. We generalise sound based on what has come before it, constructing music from a patchworked complex of seemingly recurrent sound events, referentially deploying these abstract data to qualify and organise new material input. If listening is the fundament of musical design, and discrimination the second, generalisation is the third. This hierarchical understanding of musical listening is the core *theoretical* contribution of this thesis and fully underpins the practical value of this research project.

redundancy and risk

Ending each main-body chapter of this thesis is a patterned approach to assess ‘redundancies’: qualities that generally exist across my portfolio and are therefore contained self-similarly throughout my practice. Seemingly, no matter how complex music systems get, they are still practically composed of core and repeated elements: things that we can perceive as singular or strongly correlated. This systematically echoes Christensen’s (1996) idea of perceived regularity in musical listening. As a defining characteristic of more complex structures, the perceived regularity of sound is responsible for ensuring the construction of higher-order materials such as pitch content and pulse, themselves constituting yet higher structures of melody and rhythm. This latter mutation occurs when Christensen’s regularity is set against ‘change’: listening dimensions achieved through consistent regurgitation of material form into more complex and satisfying structures when tempered by the expanded possibilities of variety (i.e. consistent irregularities of pulse mapping to the production of rhythm). Navigating this spectrum produces complex features of musical experience: discrepancies of pulse perceived as rhythmic structures, then forming melody when supported by transverse and predictable movements in pitch height; pitches clumping together to form the basis for harmony; accelerating pulses fusing into pitch, then decelerating into perceptually discrete sound events; sound masses formed by large ensembles playing short bursts of sound at slightly different intervals; etc.

The assumption here is that a core foundation of musical experience lies in the perception of similarity and difference, and over-adherence to either extremity of this continuum results in tedium on one hand and chaos on the other. The same risks apply to my process of identifying abstractions. In Chapter 01, it was made clear that, while fruitful, basing works of music on familiar sounds can hinder the creative development of the piece; tightly defined boxes of sound can be hard to move out of. The timing systems built into works of music extend the degree to which sound can be articulated by computers, but can lead to normative understandings of how time functions. Collaborative approaches to compositional practice, as found in Chapter 03, can extend the degree of skill and experience that can positively impact the work, but can also lead to a stifling range of options. The range of social relations that can be musically exploited may extend the socially aesthetic function of the work, but can lead to claims of the usefulness of music simply because it is social. Aesthetic sensibilities can be (conceptually at least) woven through any piece of technology utilised in a work, but this perspective can shift focus from music onto technology. Each chapter of this thesis had to reconcile this in one way or another: under-abstraction (too much variance) leading to too many options and under-abstraction (too much regularity) leading to too few (sickening chaos on one hand and totalising order on the other). Music system design is a practice of finding workable models that exists between these two extremes: a process of composing abstractions.

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00069

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Appendix A - electronic sound techniques

This appendix covers types of digital sound processing approaches that I often use in my compositional practice. I provide a simple overview of how the software works, an evaluation of the general musical affordances of the tools, and a short description of how I personally use these tools musically,

gutter synthesis

Gutter synthesis “a synthesis method that combines chaotic synthesis based on the Duffing Oscillator dynamical system with modal-like resonances” (Mudd, 2019, p. 167). Developed by composer Tom Mudd, it can be understood as an overlap between ” chaotic synthesis on the one hand and physical modelling on the other” (168). This system provides a means of producing complex harmonic or rhythmic material, strongly reminiscent of acoustic sound sources. Musically, I use this tool as a way of generating complex harmonies, complex and shifting patterns of rhythmic pulse-like sounds, and disgusting digital feedback.

corpus based concatenative synthesis

“Corpus-based concatenative sound synthesis uses a large database of source sounds, segmented into units, and a unit selection algorithm that finds the sequence of units that match best the sound or phrase to be synthesised, called the target” (Ircam, below).

“The selection is performed according to the descriptors of the units, which are characteristics extracted from the source sounds, or higher level descriptors attributed to them” (Ircam, below).

In context of my work, this approach to synthesis is used to produce complex sounds that are referential of the sound quality of existing recordings. This is useful for generating material redundancy between live musical performances - or recordings therefore - and a stream of granular impulses.

Corpus-based concatenative synthesis is an intelligent method of granular synthesis, that takes sound from an input corpus, slices it into small fragments or ‘units’, and then rearranges these fragments according to a target specification. Typically, each fragment is assigned an ID to indicate its place in a buffer, and the target produces a sequence of ID’s that causes the output of a stream of grains.

http://imtr.ircam.fr/imtr/Corpus_Based_Synthesis

FFT freezing

FFT freezing is a method of producing fixed harmonic sounds that are harmonically correlated with the sinusoidal makeup of an input analysed spectra (see Cycling '74, below)

Musically, I use this tool as a way of processing sounds into a fixed - and practically infinite - summary of their contents; harmonic materials that reference their source but can be sustained indefinitely. There can be a pleasing and glitchy quality to the repeatedly frozen and unfrozen material.

<https://docs.cycling74.com/max5/tutorials/msp-tut/mspchapter26.html>

Appendix B - Assimilation / Dissimulation - statement on collaboration - Jack Walker

Assimilation / Dissimulation is a collaborative work for ensemble and live electronics. We wanted to compose something which made of the most out of our respective skill-sets. I differ from Aggelos in that I have no significant background in music theory. However, I do have a lot of experience in computer programming for real-time digital signal processing (DSP). As I understand it, we wanted to compose a work with a fixed score and a set of live electronic materials which were capable of altering sound in real-time. Although there was considerable fuzziness and overlap between our roles, I was responsible for designing the code and selecting particular DSP techniques, while Aggelos was responsible for producing the score. Aesthetic decisions regarding materials largely originated in our respective domains (i.e. ideas for electronic sound came up when I was working with code, with the exception for the tape part mentioned below; ideas for acoustic sound came up when Aggelos was working on the score), but were mediated between the two of us. I like to imagine this compositional process as a feedback loop between two different methods of preparing sound for performance.

We started the piece by synthesising a range of textures using Tom Mudd's 'gutter synthesis' application. We decided that we would use one of these textures as the harmonic backbone of the piece. We selected a texture (please see file `tape.02-01.wav` in `assimilation / dissimulation` code -> `diss.rehearsal-0.1.5` -> `media`), and Aggelos used spectral analysis tools to extract a set of discrete pitches (quantised to quarter tones). Aggelos then composed ~1 minutes worth of material using this harmonic information, and sent it to me as a MIDI file. I rendered this MIDI to audio with a sampler, spectrally analysed this sound file and used this analysis to inform a prototypical set of live electronics to accompany this section. I then produced some sound purely electronically, and set it to Aggelos, who analysed the content, and continued score production, etc. Roughly speaking, this is how we developed the structure of the piece. One of us would respond to an existing component by analysing it (either by listening or with sound description tools), the resulting analysis was then mapped to new musical events, and these new musical events then

became fodder for subsequent analysis. As our specifications for the piece became more tightly defined, we also began to work on a small library of sound files which could be triggered by a sampler throughout performance. This 'tape' part was designed by both of us and is exclusively made from recordings of gutter synthesis. To briefly reiterate, the work is comprised of three primary components: the score (produced by Aggelos), the code (produced by myself), and the tape sound files (both of us). (Please see *assimilation / dissimulation code -> diss.rehearsal-0.1.5 -> media* for tape files). (*N.B. these file links are meaningless in the context of this PhD submission, and are only included for the sake of completion*).

The code was responsible for cuing and implementing changes in electronic sound material. It exists as a small library of MaxMSP abstractions for event sequencing and DSP, and an interface for structuring these low-level abstractions into complex sound events. For sound processors, we used a network of delay lines in a structured feedback loop. The time interval of each delay line was set by MIDI pitch data, meaning that specific pitches would be produced as sound began to feedback through the unit. This was used to simulate fixed pitched content from unpredictable or chaotic inputs. We also used a bank of waveshape distortion units to heavily distort sound input. This distorted sound was then filtered by a bandpass filter, with its cutoff set to a MIDI pitch value. If the filter's resonance parameter was set to a suitably low level, and the input was sufficiently high in amplitude and spectral bandwidth, then any sound input would produce a fixed tone in accordance with the input MIDI value. Again, this allowed us to ensure fixed harmonic content from unpredictable sound inputs. We also implemented ring modulation, additional wave shaping, and audio filters. These were primarily used to thicken the texture of the sound to taste. The musicians of the ensemble were responsible for providing input to these DSP effects. As a general rule, we assigned delay lines to string instruments; distortion and bandpass filters to the piano; and ring modulation to the clarinet. Finally, we implemented a sampler to play back our tape part. Prior to performance, we established an order in which to bring in or trigger different electronic sound materials. We implemented these cues as code which could automatically move between presets of parameter data. Roughly speaking, we navigated from textural tape materials and delay lines towards a thicker electronic texture which is then punctuated by a gestural solo tape part. Electronic sound then begins to dwindle around a minute after this, leaving only some delays, some light distortion and a sub-bass tone in the final section. As the piece was performed, Aggelos followed the score to keep track of cues, as I instantiated these changes and balanced the levels of the various sound processing units.

Appendix C - Artist Statement- Aggelos Mastrantonis: Assimilation/Dissimulation

The conception, development and realization of the piece Assimilation/Dissimulation arrived as a byproduct and in relation to the material conditions of the time. We began toying with the idea of making a collab piece for Dialogues Festival 2019 around the beginning of semester I. Both Martin Parker & Peter Nelson wanted to have us on board for a day that would focus on works from PhD Composition and Creative Music Practice courses, and we were basically given total freedom on what we would do for the 'Rush Hour Concert', within a reasonable budget- we'll come back to that. I believe that our first discussions with Jack were on a bus to Leith and probably later at the pub. He wanted to have a piece for his portfolio using live instruments, and I wanted to make a piece using live electronics; so we thought we could piece a work together, instead of having 2 separate works, happening on the same concert. I think I recall the term 'fully luxury gay space spectralism' being tossed around. We were both reading Fisher, Zizek & Baudrillard at the time, so it made sense.

The initial concept involved a quite simplistic d.i.y. setup. Violin & Guitar, maxmsp patch and whatever additional equipment we could book from the ECA store. We only really had the ECA Western Court venue, a time and a date, but it was Peter who later came to conduct the event's works- that encouraged me to see if we could perhaps get an ensemble for the performance. He was on good terms with some undergrads from the string orchestra and did mention that he could perhaps persuade one or two alumni to contribute as well.

So, once we had the concert pretty much booked, and a vague idea on who would participate (performers and composers) we had to look for funding sources. And we got it! We weren't really expecting to be granted that much money, both the ECA devolved fund and the PG research funding applications were successful, with a sum of £6,500 or thereabouts. I remember reading the confirmation e-mail and immediately started screaming. There is probably an e-mail responses chain discussion from that day between Jack, Eleni, Martin and me which read like 'AAAAAA',

‘FUUUUUCK’, ‘YEEEEEE’. You get the picture.

That was when we got quite serious about the project’s scale: 7 performers, 5 composers, 3 sound engineers & quad speakers. We booked the Reid Concert Hall, and Robert Irvine from Red Note joined us during the rehearsal period for a coaching session. We even managed to afford artist fees for the musicians! Martin was happy to let me curate the closing gig of the festival, and we managed to book the avant-jazz act Mob Trio from Athens to perform on that day.

From that point on, after the successful funding application our lives became truly hectic. Curating, organizing, planning and composing for a contemporary music festival is challenging enough on its own, let alone while also trying to balance between academic research, teaching and a couple of part-time jobs to make ends. We would usually meet on our days off from uni and work, run the logistics and work on the event plan for a couple hours, and then sketch/compose/discuss on the piece for as long as we could, then hit the pub. I think I slept for 2 days straight after Dialogues. I’d do it again on a whim.

For our first tests/demos we booked the Alison House Studio. Jack was in the booth, and I was in the rec room improvising on the violin. The signal was processed via Gutter (the max subpatch developed by Tom Mudd) and the generated output was returning as a feedback loop also directed by the code. The recording sounded like shit. We figured that it would be even worse had inputs from other physical instruments were thrown at will into the processing unit, so we needed to see for a different strategy. We still wanted to use Gutter- mainly because it was so unpredictable, fun to play with and niche interface as well - and then work with another system for the ensemble processing. This is what we eventually decided: Jack would run a series of short improvisational ‘shots’ on Gutter using a simple input (like bleep or a plain sine). We would record the audio output and then just would pick 1 or 2 excerpts, no longer than a minute long, that would pose as the main source for the piece, the epicentral sound, and the centrifugal force for both the generated score and any potentially additional tape parts.

Interlude/contextual tangent: In my most recent research and compositional practice I work extensively with pre-existing material(s), while I am particularly interested in the extensions of semiotics towards cultural synapses. It’s a twofold question where one part has to do with identification and the other with alienation; more in relation to the appearance of a said ‘thing’ or an ‘object’ rather than its function, or even the fidelity of that function, comparative to the framework of (a) tradition.

The piece I wrote just before ‘Assimilation/Dissimulation’ was ‘Chere Leonore’ for piano solo. It was grounded on a transcription of a French folk song called ‘La Belle Nanon’. The vocal line was harmonized in a simple 4-part traditional fashion. Embellishments, including appoggiaturas, suspensions and non-harmonic tones were added. The part was further developed by alterations in tempo markings, compound time signatures, substitutions and prolonged arpeggios. On the last stage of trans-

mutation, the narrative flow was itself fragmented further, either interrupted or juxtaposed to the ‘response’ interjected composed material. The intended result was for a structure which subsumed the piece within a piece, or perhaps a piece that could have been, echoing and thus hinting towards the original folksong, though compressed beneath a layer of neutrality and gradual, glacial-like spectral territorial movement.

My commission for Dialogues Fest that followed ‘Assimilation/Dissimulation’ was the ensemble work ‘2 Preludes for Lamai Bada Yatathana’. With this piece the transcription works as the narrative mechanism analogous to a Chekhov’s Gun. After copying and arranging the traditional Al-Andalus song, the query was on ‘how do we get there’ instead of ‘how do we integrate it within a contemporary music idiom’. Thus, I tried to isolate individual secondary elements (embellishments, trills, glissandi, melodic excerpts) and revolve the prelude material around and through those elements in an episodic form. The affect of being able to *a posteriori* identify materials derived from the transcription, that were implemented as gestures within those episodes, would reveal the structure of the piece at the moment wherein the original melody was displayed in its entirety.

So, if ‘Chere Leonore’ was a piece about submersion and ‘Two Preludes...’ was about determination, in ‘Assimilation/Dissimulation’ we are witnessing the total integration of the pre-existing material with its anacrusis from the separate medium (the ensemble) via a self-referential re-orientation. And it is through the abstraction between the two (model- replicas) that the movement of the piece is revealed. The ensemble constantly returns to imitating the audio file produced by the Gutter Improv (I think we called it ‘high- 01’ or some similar really-not-so-sophisticated name) not only in regards to pitch and envelope, but also at the sample’s imperceptible rhythmical motion and modulation. Each time the ensemble attempts to mimic the sample, the result produces a different output, as it is similar and, consequently, not the same, hence developing opposing relationships between the replicas themselves. A relatively small alteration, or intentional ‘flaw’ in each copy- regarding even one parameter e.g. pitch- might result in a harsh dissonance at the moment of juxtaposition with the sample, moving from enhancement and amplification to conflict and dynamic abstraction.

And looking back at it, I think the subverted nature of the piece is what really made it shine: Following the performance Martin described it as both ‘atmospheric and seething’, and he was quite right to do so. It is exactly temporality wherein one labels the piece as ‘drone’ or ‘ambient music’, in attempting to experience the performance as a static entity, a musical bed- or some other bizarre non-musical analogy- if you like, that, in eventuality, would begin to realize that there might be a lot of action happening underneath those bedsheets.

Before I return in describing the compositional process, just a couple of notes regarding the individual roles. I was responsible for producing the score, and Jack

was responsible for the code. We wrote the tape parts together. But there was overlap in our duties. I mean to say. I can't code for shit, but I can understand how I want live electronics to function, as mechanism in service to the work's dramaturgy. Similarly, I believe that Jack might not be as familiar as I am with producing scores using notation programs, that being said, there were quite a few instances where I would receive feedback on the midi drafts, that read along the lines of: *'The cello entry in bar 17 happens a bit too early here, we need less of an attack, faster crescendo and the glissando needs to reach A instead of B-flat. Clarinet is too loud as well. Passage might also work on a slightly slower tempo overall'*. Now, those are very precise directions; I would do the suggested changes and it usually sounded better indeed. I am not in a position to draw lines as to if directions such as these constitute scoring, or aid towards scoring- I suppose it is a question of causation and causality- yet it was good enough to edit specific parts and keep the ball rolling. My feedback to the audio files I was receiving in return, after the DSP or the interface, was also equally precise: *'High pass this', 'Sounds too muffled', 'Too little overdrive here'* etc.

By this point we had established that we would take the specific sample ('high-01) as the main source for the piece. After the analysis of pitch material from the audio- in quartertonal quantization- the transcribed pitches can be seen on the left-hand side of the first staff of 'table of spectral materials' document. Common tones between the audio and the harmonic series of C & A $\frac{3}{4}$ flat are displayed just below, second staff on page 1. Our intention was to generate a spectrum that would be tonally phasing in and out of the string part spectra, insinuating an interplay between triggered DSP and live performance, by generating harmonic and/or non-harmonic overtone amplification veiling the string parts. A table of delay lines' pitches that correlate with abstracted sets from the re-arranged C/A $\frac{3}{4}$ flat overtones and the Gutter audio sample can be seen on page 2. We eq'd and selected, I believe, 4 of those delay lines sets to trigger in different cues during the score run via a sequencer, while Jack was moving through the presets and controlling the faders and eqs. Overdrive and ring modulation effects applied to Clarinet and Piano parts were intended to highlight the signal processing effect.

As for the macro-structure we came up with a form along the lines of: Tape & Low Strings/ Signal Processing (Delay Lines & Ring Modulation) & Everyone/ Dry Signal/ Dry Signal & Tape/ Tape (solo)/ Signal Processing, Tape & Everyone/ Dry Signal of Strings & Clarinet/ Signal Processing & Everyone (with heavy piano overdrive).

Without going into too much detail regarding the scoring, and returning to notions of self-referentiality, transcription and imitation, during the opening gestures of the piece, the ensemble produces pitches that correlate to the common tones between the 2 harmonic series (see the B $\frac{3}{4}$ flat and the open D string of Double Bass and Cello parts correspondingly, in the first few bars), while in bar 13 this material is distributed among strings and clarinet as the audio sample 'high-01' is triggered. In

bar 100, at the point of the ensemble's re-entrance, by doubling the super-minor 7th resonance of the tape part, the function leans towards a subdominant/ super-tonic affect. Compared to the common tones pitch set ('table of spectral materials' page 1), the pitch class can be understood as a transposition of the 2 upper common tones (a major 2nd plus a $\frac{1}{4}$ tone above the displayed table registers, and thus the supertonic vibe) with the transcription's inverted low tone (D moving to E) now as the upper layer, displayed by Violin I from bar 106. The Hidjajj (or double harmonic) tetrachord formed by the dry signal strings from bars 138-139 was derived from the mid registers of delay lines of set no. 4, also referencing the 'high 01' sample (if we alter registers and re-configure B $\frac{1}{4}$ sharp to C $\frac{1}{4}$ flat). The piece concludes with the tones E on Violin II and F $\frac{1}{4}$ sharp on Double Bass from the common tones of the 2 harmonic series and B $\frac{1}{4}$ sharp on the Violin I (with Viola doubling 3 octaves bellow) and G (Clarinet) replicating the 'high-01' audio excerpt, in a sense attempting to synchronize and consolidate features from the 2 distinct sonic territories for the work's epilogue. The above were mere examples of the ensemble producing materials in concordance with pre-existing sonic features and spectral resonances, heard throughout the piece as parts of the delay lines. Those were however pivotal moments in the piece (beginning, midway re-entrance, dry signal strings, closure) sketched as axes, waypoints to orientate through the compositional structure. I would be most certain that an analyst could probably identify a dozen more passages verging towards a categorization of such function. However, one needs to underline that in gestures wherein the ensemble is producing output outside those parameters, the desired outcome was one of conflict and dissonance as stated previously. In any case, the functionality and appearance of scoring material within the dramaturgy can be comprehended by and through their relation to those displayed on the 'table of spectral materials' document, as they are pivoting from and are always comparative to them, either as interlinked copies- by sharing enough common pitch elements- or as simulacra- being outside the pitch territory- as well as during the motional relationships formed at the space in-between those signifiers.

It has already been hinted that 'Assimilation/Dissimulation' worked as an additive feedback system on every level of production. The scoring was derived from and references the Gutter audio file, which, in turn, was a byproduct of feedback loops. The pitch class sets of the delay lines were produced by the feedback cycles of the input's delay and were themselves being emulated by the ensemble. The collaboration between Jack and myself had itself a fair share of back in forth in the exchanging midi files from notation program and audio outputs including the DSP. The slow pacing of the work's progress was decided, stemming from a desired outcome which aimed towards a permanent re-orientational movement between the extremes of the work's dual nature, via its palindromic motion either inside or outside territorial spectral class, amplification and contradiction, static and erratic, copy and simulacrum.

We tried to keep both the code and score as simple as possible. As a matter of fact we

kept repeating like a mantra, phrases such as *'Don't overdo it'* or *'Let the sounds do the work'* and *'Keep it simple, keep it real'*, and I think that had we have attempted fancier, more complex approaches either regarding the generated notation and/or live processing, the artistic result would have been so much less impactful in outlining this movement between the 2 poles, compared to what we ended up in producing.