User Serviceable Parts

Practice, Technology, Sociality and Method
in Live Electronic Musicking

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Declaration

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Abstract

In live electronic musical research there is a need to confront the interrelationships between the social and the technological in order to understand our music as practice. These interrelationships form a complex and dynamic ecosystem that not only forms the context to, but is constitutive of practice. I interrogate from a variety of perspectives the musical practice that has formed over the course of this research in order to reveal the dispositions towards technology, the social situatedness and the musical approach that underlies my work.

By taking a disposition towards musical practice-led research that is non-hierarchical, performative, ecological, phenomenological and pragmatic, I place into wider context compositional and technological decisions, in terms of their relationships to improvising, skill, design, performance and research.

This work contributes both new theories of live electronic musical practice and new suggestions for practice-led methods aimed at investigating the interplay of social and material factors in musicking, and at interrogating the disciplinary status of our field *vis-a-vis* musical and technical disciplines.

Introduction

At some point in 2005, having sat in a studio for most of the preceding year preparing fixed-media pieces of electroacoustic music, I realised that I was not enjoying myself sufficiently. There were two bases for this, each of which informs the research discussed in this dissertation. The first was technological, in that I was finding that the experience of through-composing pieces in a digital audio workstation (DAW) fitted poorly with my inclination to improvise, and that, moreover, I had a nagging feeling that there was more to the interrelationship of music, technology and their surrounding social configurations than the take-it-or-leave-it neutrality-or-determinism I had encountered up to that point could account for. The second basis was social. I was increasingly aware of the extent to which, for my traditional musician (as in folk) friends, music was more readily and spontaneously available as a way of being social and that this added considerably to the richness of their practices, beyond the activities of composing and performing. Consequently, I resolved to step out of the studio and develop an improvising-composing practice in live electronics with these bases in mind, and a somewhat hazy notion of how they interrelated.

Some years later and I can, at least, claim to be able to articulate some of the qualities of these interrelationships between musical practice, improvising, technology and sociality insofar as they obtain to my music making over those years. This research has yielded the accompanying portfolio of computer-based pieces for improvisers, but has also yielded a *practice* that I take to be manifested in a disposition towards my tools, socially situated, and to extend into daily life more significantly and fulsomely than can be accounted for by catalogues of works or performances. As such, this dissertation sets out to present my research as practice, and to be an investigation into the nature of this practice: I attempt to make apparent the disposition towards tools, social situation and diachronic extension in to daily life that has formed, and to use

this as a basis for exploring the particular choices that produced the portfolio pieces.

The stance that I have developed owes a great deal to encountering the work of Christopher Small ([1977] 1996, 1998) and his idea of *musicking* at an early stage of my research. Small's usage of this term stems from an analytical position, similar to that present here, that regards as inadequate the orthodoxy of treating music as a set of more or less fixed *objects*, such as scores, recordings or performances. Instead, Small is concerned with music as a *practice*, as a process of human relationships in which musical objects are involved. This notion is especially apposite to the examination of improvised live electronic music because our objects are so mutable; there is no clear work concept that can be used as an analytical basis and, moreover, even instrumentation is liable to change sometimes quite suddenly and radically, and sometimes within performance.

The term *musicking*, then, is deployed to highlight this idea of music as a verb and, following Small, the reader will notice that I occasionally use *music* as such in this text—I music, you music, and so on. In some respects, this work seeks to build upon the ideas presented in rather general form by Small (1998), by treating musicking as a set of rituals in which networks of relationships are at play and by recognising that musical agency extends beyond those immediately concerned with playing or composing. As a result there are continually present throughout the text a number of dispositions towards musicking that have formed over the course of this research, in that I have pursued an approach that is *non-hirearchial*, *performative*, *ecological* and, *phenomenological and pragmatic*. These may serve as good themes through which to introduce the remainder of the dissertation,

Non-hierarchical

The perspective on music making that has underpinned this research is *non-hierarchical* insofar as a range of common-sensical musical hierarchies are treated with critical—yet pragmatic—scepticism. For instance, it would be tempting to declare that the central role of improvising in my practice constitutes an egalitarian musical politics in and of itself, and thereby contributes to an overturning of the interpretative hierarchy of composer-performer-listener. However, I share with John Bowers (2003) the belief that such a stance is idealistic in practice. Improvising seems to be no more immune to the emer-

gence of unhelpful power relationships than any other activity in capitalist culture. Nor does it seem to go without saying that all hierarchical relationships are, at all times, deleterious. Consequently, the general approach taken to such hierarchies can be characterised as agonistic, rather than implacably antagonistic: if, in practice, hierarchies between various musical agencies are apt to emerge, then my stance is orientated towards maintaining a productive instability, in order to militate against these hierarchies ossifying into power relationships.

In Chapter 1, two such hierarchies are thematically present; the composer-performer-listener hierarchy already mentioned and—more implicitly—the contested difference in musical status of composing and improvising respectively. The latter relationship informs substantially the approach taken in this chapter. I eschew an approach to composing and improvising in abstract terms but instead choose to illustrate my musical relationship to these activities through a series of first-person accounts and reflections. In this way I avoid the tendency to present them as opposed ways of music making, which can arise when the discussion proceeds from a reduction to ontological essences. Instead, I am able to explore the extent to which these categories and their associated ways of acting have intermingled in my practical experience. Furthermore, I am able also to probe concretely interpretative hierarchies as they arose in practice, most particularly in terms of the relationships between composers and performers or co-performers, and between performers and listeners, as well as the ways in which the networks of mediation we encounter in musical culture make these relationships more complicated.

A distinct set of hierarchies comes into focus in Chapter 2 where I turn my attention to the relationships of musicians and technologies. I follow Simon Waters (2007) in expressing anxiety that valorisation of the digital present can obscure practical and analytical opportunities to identify and capitalise upon continuities and valencies with a wider range of music, as well as in probing this valorisation in terms of the relationship between performers, instruments and environments. By paying particular attention to how these divisions relate to notions of skilfulness I seek to render problematic hierarchies of technological epoch and of human versus machine. I argue for an understanding of musical skill that emerges from complex, culturally situated, negotiations rather than from the attribution of innate and invariant giftedness.

In Chapter 3, I examine the particular interactional forms that my portfolio pieces afford, and relate these to the formation of my musical priorities.

In each piece, I am broadly following the path beaten by George Lewis (1999) by pursuing non-hierarchical relationships, insofar as there is the possibility for any actor, human or machine, to be 'in charge' from moment to moment. This can be identified on three distinct levels. First, I have aimed for a sense of variable interactivity (Bowers, 2003) in the portfolio, such that musical roles and agencies are not predefined, but arise and change in the process of play. Second, the respect I show for technical correctness when developing patches and instruments is a also variable affair, following from my argument in Chapter 2 that different ways of knowing technology emerge in practice. Finally, I reflect critically upon how my labour can be divided between technical and musical practice, and how easy it has been to end up in service to the technical at the expense of the musical.

Performance becomes the focus in Chapter 4. I note that as performance contexts are liable to give rise to a number of of *ad-hoc* collaborations, new relationships and potential hierarchies open up. One particular focus for how this happens is centred on the critical importance of loudspeakers for electroacoustic music, the extent of variability in how they are provided in different types of performance context, and the impact this can have on the music that is made. An example of an *ad-hoc* collaboration that can emerge from this is between sound engineers and performers, which can in turn be fraught with conflict (Frith, 1996). It follows from this that there can be an operational hierarchy of the settings in which musicking happens that is based, for instance, on the sophistication of available technical infrastructure and the degree of autonomy afforded to artists. I suggest that better infrastructure and greater autonomy also tend to come with particular social codes, and that different social codes can provide different musical affordances.

In Chapter 5, I reflect upon the productiveness of the methods I have used to present this research. I consider the status of practice-led research in live electronic music as an inter-discipline, and wonder how such research could be practised and disseminated in service of musical conviviality. At work here, following Ivan Illich ([1973] 2001) and Andrew Feenberg (2002, 2008), is a critique of the kinds of specialist hierarchies that contemporary technocracy supports, most especially in mistaking local expertise for universal authoritativeness. Music is extraordinary for the degree to which its practices occur across social and institutional boundaries, but it seems as susceptible as any other aspect of contemporary activity to be segregated by privileging certain types of specialist understanding. Acknowledging that practice-led

research within the academy confers a range of privileges—such as room to be speculative, institutional shelter, and access to resources and authorised discourse—I ask if there are ways of conducting research that do not reproduce such segregation.

Performative

A feature that underscores my approach to music's various hierarchies is the diverse ways in which music is *performative*. This encompasses the obvious sense that music is a performance art, but also the sense in which performativity is understood in a cultural studies context as concerning the ways in which actions and deeds give rise to, or reproduce, identities and relationships. In this respect my stance has been shaped in particular by the work of Christopher Small (1998), Simon Frith (1996) and Tia DeNora (2000). All these authors articulate senses in which listening is itself a performative act. Small, in particular, captures the way in which repeated instances of particular types of performativity (e.g concerts) give rise to rituals whose constitutive relationships are obscured by habituation.

Feenberg (1999, 2002) offers a complementary perspective *vis-a-vis* our relationships with technology. He notes that for all that modern technologies may seem geared to insulating people from the effects of their actions, for instance by prioritising effortlessness, there is a reciprocal process of identity formation at work as the characterisations of our technological interactions shape our disposition to the world at large. Feenberg has since gone further by enlarging the scope of his analysis from a focus on technology and considers how the same arguments apply to the principles and practices that constitute the dominant understanding of rationality, such as markets (Feenberg, 2008). I take this enlarged perspective to be of significant value for the study of electroacoustic musicking, as it provides a means for thinking critically through our technological relations in a way that is contiguous with the 'performative', in the sense used by cultural studies, and prompts us to consider the technological and technical in a much wider sense.

A performative understanding is at work throughout Chapter 1, and is, again, evident in my rationale for pursuing an experientially grounded, rather than ontological, treatment of composing and improvising. I am concerned with how being embroiled in these activities has formative consequences for the ways in which I come to understand them and my position as a participant

in musical culture. The case-studies capture at least some flavour of how these formative effects are diachronic and dispersed. For instance, my accounts of practical engagements with the work of other composers highlight some ways in which interpretation and performance were influenced by mechanisms other than the score, and my reflections on improvising situations are able to show different ways in which musical and social relationships interweave.

The technological turn of Chapter 2 treats skill, in particular, as being bound up with performative histories, not least in the ways in which the kinds of interface we make ourselves have a conditioning effect upon the musical identities and the discourses of skill we bring forth. I suggest that what constitutes competence is also a matter of social context, because social convention as well as physical affordances constitute the particular qualities of an instrument. Nick Prior (2008) argues, for example, that a performative aspect of certain electronic music can be seen in musicians using the symbolic capital of their technologies to perform a particular kind of knowingness.

In this sense, Chapters 3 and 4 can be read as a situated case study of such conditioning effects. In Chapter 3, I trace the development of my portfolio pieces from their starting impulses, through their technological engagements, to the point of trying to do something *musical* with them. I highlight a tension that emerges between the identities of maker, on the one hand, and musician, on the other, as I negotiate my musical desires with respect to my technical means. In my particular case, I locate this tension in my relationship to practising, in the vernacular musical sense, and identify the need to cultivate a disciplined and habituated approach to this in a context where instruments and practices made unstable by being always available for modification.

In Chapter 4, I conduct a similar exercise by examining how public performance of the portfolio pieces fed-back into their development, and into forming my musical priorities. In particular, I examine how particular arrangements of space and technology interact with the performance of musical identities, and how the particularities of the *soi disant* experimental music concert might give rise to particular musical priorities and occlude others.

Performativity features in Chapter 5 in two distinct ways. First, as part of evaluating the kinds of knowledge claims such research is able to make, which are cast by Barbara Bolt in terms of performativity (Bolt, 2008). Second, I return to the relationship between musical rituals and identities in my closing discussion of musical conviviality.

Ecological

The performative perspective I describe above arises through recognising that musical identities and proclivities are bound up with, and formed in the context of diverse and complex meshes of relationships between people, technologies, histories and ideas. In this, it constitutes part of a wider *ecological understanding* of music that I have arrived at over the course of this research. This has come about on two fronts. First, from the musical literature, I was exposed to the the ecological thinking of Gregory Bateson and James Gibson via the work of Small (1998) and Eric Clarke (2005) respectively. I was also introduced to Timothy Ingold's wide ranging account of our environmental situatedness (Ingold, 2000) by Simon Emmerson (2007). Meanwhile, earlier encounters with Agostino Di Scpio's theoretical writing (Di Scipio, 1998, 2003) brought me to the theory of living systems developed by Humberto Maturana and Francisco Varela (Maturana and Varela, 1992), and the later 'enactive' theory of mind put forward by Varela, Thompson and Rosch (1991), alongside the 'extended mind' theory of Andy Clark (1997, 2008).

An important value of these theories is that they allow for acknowledging the *irreducibility* of certain entities into what may seem to be their functionally salient properties; so, human *being* can not be adequately accounted for as an aggregation of cells and chemical processes (Maturana and Varela, 1992; Ingold, 2000), and various levels of social collectivity do not reduce neatly to aggregations of individuals or of smaller groupings (Born, 2010a). The fertility of such perspectives can, however, be potentially overwhelming. Pragmatically, in both formal and everyday analysis, it is necessary that we make conceptual cuts in the network of connections in order to cope; of equal importance however, is to remain alert to the contingent nature of such boundaries, as explained elegantly by Lucy Suchman:

> How far our analysis extends in its historical specificity and reach, or in following out lines of connection from a particular object or site to others, is invariably a practical matter. That is, it is a matter of cutting the network, of drawing a line that is in every case enacted rather than given. The relatively arbitrary or principled character of the cut is a matter not of its alignment with some independently existing ontology but of our ability to articulate its basis and its implications (Suchman, 2007, 284).

So, in Chapter 1, it is such a perspective that leads me to focus on the situated act of making music as a fertile site for *thinking* music, by attending to the perceptions afforded by my actions. In this respect I am following Small

(1998), who insists on treating as *musically significant* the participation of any person to a musical event, however slender, so prompting us to consider the whole gamut of relationships and meta-relationships in action. Whilst I am not so comprehensive, I nonetheless explain disparate and distributed sets of relationships as being significant to the musicking I describe.

In Chapter 2, I argue for treating the performer-instrument-environment as a network of relationships, following Waters (2007) and Bowers (2003). I use aspects of Clark's argument for the environmental extension of our minds to propose that the boundaries between these entities are dynamic (Clark, 1997), and Ingold's accounts of making, 'enskilment' and 'wayfinding' (Ingold, 2000, 2006) to discuss characteristics of interaction with musical technologies.

Chapters 3 and 4 use these perspectives to explore in detail the particular ecosystems of my portfolio pieces. I have been influenced significantly in my approach to designing systems by Bowers, who puts forward the idea of a 'performance ecology' for analytically framing the resources he brings to improvising, and by Agostino Di Scipio (2011, 2003), who has approached the design of some pieces as 'audible ecosystems' as part of a critique of more commonly encountered control-orientated approaches to digital musicking. In these chapters, then, I explore both the ecosystems I have designed, and reflect upon this design work in the wider ecological context of situated experiences of practice.

Finally, in Chapter 5, this ecological disposition inflects my assessment of this research insofar as I treat it as enrolled in related ecosystems of scholarly and musical practice and am concerned to develop approaches that promote collaborative sense-making (De Jaegher and Di Paolo, 2007) between agencies in these ecologies.

Phenomenological and Pragmatic

Finally, then, this work is *phenomenological* and *pragmatic*, both in approach and in the extent to which its theoretical apparatus is underwritten by the work of phenomenological and pragmatic philosophers. In the first respect, much of the work is straightforwardly phenomenological insofar as it is concerned with the phenomenon of my practice through the lens of experience, rather than seeking an explanation in terms of causes. This emphasis on experience has also arisen through the influence of the pragmatist approach to aesthetics of Richard Shusterman (2002). One particularly valuable contri-

bution of Shusterman's is a powerful argument in recognition of the plurality of possible interpretations of any given aesthetic experience and the ways in which these interpretations arise as a historically and socially situated negotiation. This position has a good deal in common with the ideas of performativity discussed above as well as usefully allowing me to acknowledge the contingency of my theorising.

In Chapter 1, as already mentioned, I avoid theorising composition and improvisation as abstract entities, and come to an understanding of them by reflection upon a range of experiences. Similarly, in Chapter 2 I am concerned primarily with the experiential truth of treating instruments as potentially far flung coalitions of disparate resources rather than as single resonating objects.

Chapter 3 takes as its starting point phenomenology as practised by David Sudnow in *Ways of the Hand*, which gives an account of the experience of learning to play piano (Sudnow, 1978); I adopt a similar stance in providing an experiential account of the formation of my portfolio pieces. This stance is maintained in Chapter 4 by relating how experiences of performing contributed to this formation.

Chapter 5, on the other hand, is not an experiential account, but is nonetheless phenomenologically inflected in that I argue for the contribution that experientially grounded reflection from practice-led researchers can make to the musical research community. Meanwhile, I take a pragmatic stance and regard as unproblematic the plurality of perspectives that practice-led research of this type may yield, and suggest their usefulness as complementary rather than competing explanations for phenomena.

Overview

The dissertation is formed of two parts. Part I, formed of Chapters 1–5, comprises the discursive component of this research through its discussion of practice, technology, sociality and method. Part II, Chapters 6–10, consists of commentary and technical documentation of the portfolio.

Part I may be helpfully conceived of as having two 'movements'. Chapters 1 and 2 form the first part, and establish a ground for what follows. In Chapter 1, I illustrate my musical context through first-person accounts so that I might make my general orientation to composing and improvising apparent, and so that my musical goals can be contextualised alongside both the literature and my history of practice. In Chapter 2, I deal with the most theoretical aspects

of this work, which relate a philosophy of technology to a socially-grounded account of musical skill, and provide a rebuttal to a tendency towards uncritical valorisation and differentiation of new musical technologies with respect to old.

The second 'movement' is formed by Chapters 3, 4 and 5. These are thematised under the headings of *Grabbing*, *Holding On* and *Letting Go*, and deal respectively with the development, performance and distribution of this research. In Chapter 3, I deal with the particular material practices that gave rise to the portfolio pieces, and detail how they were shaped by practical contingencies. In Chapter 4, I perform a similar exercise, examining how experiences of performance helped form this research. Chapter 5 focuses on research itself, and discusses how this work might be understood in terms of discourses around practice-led research and interdisciplinarity.

Chapters 6–10 take each piece in turn, in the order in which I started work upon them. Each follows the same basic format. After introducing the piece in general terms, some contextualising explanation of the recording is given. First, in terms of why this particular version was chosen from those available and, second, as a commentary of the music itself. This is then followed by technical documentation of the piece that takes the form in each case of some basic performance instructions and a detailed description of the operation of the supporting software.

Part I

Practice, Technology, Sociality and Method

Chapter 1

Composing Improvising

I begin with a collection of first person accounts of playing in different situations. The chapter is structured around two sets of these first-person accounts: one that details engagements with indeterminate works by other composers, the other with structures arising out of improvised settings. These 'case-studies' are followed up by interim reflections, and the chapter closes with the development of a (contingent) theoretical account of the interrelationships between, and affordances of, composing and improvising so far as my live electronic practice is concerned.

There are two reasons for taking this particular approach. The first is to find a way of looking at the activities of composing and improvising without getting sucked into an ontological discussion; I am not especially interested in general definitions at this point—I am not even sure that they are possible. Instead, I am interested in capturing particularities as they have pertained to my experiences of practice and that will, in turn, provide useful contextualisation for the compositional decisions I have made.

Second, the reason for first person accounts in particular; is it my contention that, as a matter of methodology, adequately representing practice-based research might require different approaches to languaging and writing about musical experience than those normal to most academic discourse (in this I follow Katharine Norman and John Bowers). Consequently, these accounts knowingly side-step norms of academic style, in favour of trying to impart some impression of the tension, pathos, bathos etc. on the reader. Rest assured that the intervening sections will respect academic norms.

1.1 Case Studies I: Di Scipio, Wolff, Stockhausen

1.1.1 Di Scipio: Audible Ecosystems

'Is it working'?

This is, so far, the thematic question of trying to implement Agostino Di Scipio's *Background Noise Study*[1] in Max/MSP and perform it satisfactorily. The piece hovers ambiguously between being an autonomous, generative system and something more instrumental, that affords (demands, even) performance. This has only slowly become evident as the Max patches have been assembled—the desirable formal behaviour specified by Di Scipio does not seem to arise spontaneously, but requires judicious intervention. Given that the effects of any intervention only emerge, in an unpredictable way, after a 20-second lag, it is becoming clear that there is a great deal more *embodied learning* involved in getting to grips with this than I originally anticipated.

A large measure of the uncertainty is arising precisely because we are trying to assemble the system specified in the score without access to a working reference. There seem to be unforeseen ambiguities and differences in behaviour between Max/MSP and Kyma (on which the canonical version is implemented, and to which we have no access). As such, I am feeling mildly guilty that, in the first instance, I gave it to some students to implement, without having tried myself first; my thinking being that they would be able to get to grips with it in just a few weeks and have sufficient time left on the module to put together their own work that responds to Di Scipio's.

So, I am now a good deal more involved in my students' work than would otherwise be the case, and none of us is feeling sure of ourselves. We are finding, in particular, that the major formal feature of the piece that Di Scipio emphasises—a build up to a point of saturation, followed by a sudden cut-off and a period of silence, perhaps punctuated by small events of 'sonic detritus'—can not be reliably induced. It does not become clear for some time what the mechanism is in the software that allows this to happen.

My long-suffering students duly complete their project and manage to pull off a couple of pretty convincing performances, about which Di Scipio is kind enough to be complimentary. However, we are all agreed that it is still not behaving quite as desired, and the Max version as implemented seems to be requiring more and different intervention than Di Scipio's instructions suggest. Resolving to be better

[1] The third study in Di Scipio's *Audible Ecosystemic Interface* (AESI) series (see Di Scipio, 2011).

in future about knowing what it is I'm inflicting on students, I spend some time assembling my own implementations in both Max and Supercollider, on the basis of some reasonably detailed technical conversations with Di Scipio.

The areas of technical uncertainty narrow, but don't become less uncertain. The behaviour of one particular control signal is key, and it seems as if any likely remaining causes of errant behaviour may result from architectural differences between Max and Kyma (about which neither Di Scipio or I are sure), but that they might be small enough to disregard. However, the uncertainty is embedded now, and it turns out to be very difficult to get to a point of practising the piece that is not tentative. This is partly exacerbated because the behaviour of the piece is, by design, highly sensitive to the characteristics of the performance space, the types and placement of transducers and the set of performative gestures enacted. It becomes increasingly clear that in order to become fluent, what is required is a longish-term installation that can be left set up between rehearsals, large enough that the minimum specified six loudspeakers can be installed and driven with relative gusto. This is a set of requirements that I do not have access to, at least without renting out space and equipment on a medium term basis; the spaces and materials available to me are all communal to the department in which I work, and therefore under a degree of contention.

Nevertheless, I continue to investigate the piece from time to time with occasional guerilla set ups, when I can get space and equipment. A basic fluency continues to elude me, and I am never quite able to find a configuration with which I can rely on getting the prescribed behaviour incisively. The sounds of my attempts all belie this, as what is audible is someone tweaking a process somewhat uncertainly, rather than being able to *play*.

In other words, I cannot engage dramatically, either by accelerating the system towards saturation or by being able to draw out moments of tension. It might get to a point and then stick, oscillating around, whilst tension dissipates, or just bed in to a wandering rut, whilst the feedback process fundamental to the system sharpens a particular set of resonances in a static, ultimately dull way.

Reflections

Three particular factors arise from this engagement with Di Scipio's *Background Noise Study*. The first concerns the ambivalent status that this piece has *vis-a-vis* conventional distinctions between a composition and an instrument. The remainder both concern the extent to which it becomes clear through practical investigation the degree to which *Background Noise Study*

as a musical undertaking is underdetermined by its technological components. The second factor considers this in terms of the system's relationship with its accompanying text, and the third with more widely flung social and technical factors.

With respect to the first point then, *Background Noise Study* appears at first to be a mostly autonomous system where the performer plays more of a gentle shepherding role in which only momentary nudges are required. However, these experiences suggest an engagement considerably more continual and integrated (like 'normal' playing), yet still temporally displaced and not wholly foreseeable—more sheepdog than shepherd?

The particularities of this mode of musical action and interaction with technology and environment are not well covered in the existing literature, with the exception of Di Scipio's own contributions (for instance Di Scipio, 2003, 2006, 2011). This is in part because the approach taken in the *Audible Ecosystemic* pieces is overtly heterodox with respect to currently prevalent practices. Di Scipio sees as mostly being concerned with developing systems through determinate mappings and reproducing interactions based around command and control of which he is critical (Di Scipio, 2003; Anderson, 2005).

Because there are no clear or immediate sonic consequence to the gestural intervention of a player, AESI fits poorly with what Robert Rowe terms the *instrument paradigm* (Rowe, 2001), arguably the most common approach to live electronic musicking. Neither does the AESI does fit neatly with Rowe's other *performer paradigm*, in which the computer provides a voice distinct from (and in interaction with) that of a human performer. In this case a human performer has no direct sonic contribution, but is but one (albeit privileged) actor in the environmental context which, Di Scipio stresses, is an integral component of any given realisation, rather than a coincidental feature.

Furthermore, the AESI is distinct from what we may normally consider to be an instrument insofar as the technical network for each study is directed towards particular *formal* features (*Background Noise Study* in particular, see Di Scipio, 2011). Norbert Schnell and Marc Battier's idea of a *composed instrument* (Schnell and Battier, 2002) would seem able to account for this property of AESI. However, *Background Noise Study* fails to meet the very first of Schnell and Battier's criteria for inclusion, which stipulates that the 'gestural layer' and 'sound making layer' be decoupled. Schnell and Battier's discussion also places the locus of interest within the artefact of the computer

program itself, and therefore cannot account for the environmental coupling on which Di Scipio places such importance.

Oliver Bown, Alice Eldridge and Jon McCormack have more recently proposed the notion of a *behavioural object*, which usefully acknowledges 'the fluidity of the terms composition, instrument and performer' (Bown, Eldridge and McCormack, 2009, 195). Their scheme seems to encompass all of the above categories, as the authors seek to develop a distinctively 'digital paradigm', in opposition to an 'acoustic paradigm' (I suggest an alternative understanding in the following chapter). Although they mention the AESI as an example, the environmental coupling is unmentioned and the work is presented as being determined by its software elements. DI Scipio stresses, however, that system is represented by the *totality* of technical components in structural coupling with an environment (Di Scipio, 2011).

The remaining factors both arise from the extent to which the *Background Noise Study* as a piece is underdetermined not only by its software parts, but also by its environment and other technical constituents. The second point, then, is that the textual documentation of *Background Noise Study* is not just ancillary or descriptive, but is integral to performing the piece. This, again, only became properly apparent via practical engagement: as well as specifying the aspects of the DSP system (which was obviously vital as we were starting from scratch), the documents outline the formal nature of the work and criteria for a successful performance. Furthermore, they provide advice on the kinds of technique and intervention that may be required to get out of trouble. Additionally there is a timed score for the variant of *Background Noise Study* that involves a 'mouth performer'. These various stipulations, suggestions and structures introduce bounding conditions on the performance *in conjunction* with the technical configuration. The affordances of the software-electroacoustic network specified by Di Scipio are formed not solely by the technical logic of that network, but by their relationship to what it is we are trying to do (Clarke, 2005; Ingold, 2000)

Finally, in a related manner, there are determining factors present in neither the printed nor technical materials. First, there turned out to be a set of technological assumptions that meant certain important aspects of implementing the system were only discovered after direct conversation with Di Scipio (who was very generous with his time in this respect). For instance, it eventually emerged that implicit in the distinction between an 'audio signal' and a 'control signal' in his schematics was a downsampling operation; this

has a profound effect on the behaviour of the control signals, which are subjected before downsampling to a delay with very high feedback that produces significant oscillations. The downsampling smooths these out, and renders the system considerably more stable[2].

Further questions arise (as for all indeterminate pieces) about the role of available recordings as representing canonical, authoritative renditions to which other performances should aspire. At present, there is a single published recording, performed by Di Scipio (Di Scipio, 2005), in the studio[3]. In this instance, the recordings were clearly made with the availability of certain amount of *quiet* in the performance environment, and we may wonder to what extent this should be read as being an implicit prerequisite for successful performance. Insofar as it suggests that any audience will be, in turn, quietly attentive towards performance, this implies a particular social setting, a particular relationship between performer(s) and audience (Small, 1998).

This factor revealed itself strongly when my students gave their first public presentation of their implementation of *Background Noise Study*. Rather than explicitly shush the audience, the group were keen to bring the piece in gradually, to let it emerge. However, this presented a number of eventual difficulties; the system relies on a (nominally) fixed threshold value in a control signal to distinguish loud from quiet, and the considerable volume difference between rehearsal and a room full of talking people over-excited the system quite profoundly. Furthermore, the transformations in *Background Noise Study* are all relatively subtle, which works fine in a quiet concert, but in this case the sound from the speakers was not sufficiently different from vocal babble. This interfered with the audience settling into the kind of negotiated attentiveness the group hoped for as it took quite some time for people to notice something was happening, and more time still for the realisation that this was a performance to spread through the room.

It is worth stressing that there is not a value judgment intended here (either of Di Scipio or of the decision taken by the students). Rather, it serves usefully to highlight a way in which social phenomena can materially affect the character of musical action, and that certain kinds of insight to how this manifests can usefully emerge from reflective, practical engagement.

[2]One reason that this was not apparent is that Max/MSP has no conception of a control rate signal as such; there are synchronous audio rate signals, and asynchronous messages. Kyma by contrast, deals with synchronous control signals at a fixed sampling rate (as does Supercollider).

[3]Di Scipio also makes available, with the score, a concert recording.

1.1.2 Wolff: For 1, 2 or 3 People

The three of us are gathered in a small, windowless basement room which might be quite comfortably sized were it not for the many racks and tables of music-technical equipment we are sharing the space with. We are working through a page of Christian Wolff's *For 1, 2 or 3 People* (Wolff, 1964). I am concentrating intently upon the activities of my co-players, DMR and SW, listening and watching for cues that a sound event is about to start or complete, and maintaining myself in a state of readiness to play. Before I can do so, however, nine sound events from some combination of my co-players or the world at large need to have occurred. Then I must synchronise as closely as possible the onset of my next musical action with that of the tenth sound I hear.

Sound events duly occur, and I make my re-entrance alongside the tenth sound, accompanied by some conspicuous eye-contact and brow-wiggling to signal that I am about to play. I am immediately frustrated by the only approximate synchrony of my gesture with my co-player's, and then propelled into a slightly panicked flurry of activity. I attempt to negotiate the current system of symbols, each of which specifies a different gestural co-ordination with the other musicians (and with the sound making world at large) in terms both of temporal articulation and of mimetic emulation.

The degree of panicked flurry has, at least, eased off over the few weeks that the group has been practising this piece; the meanings of individual symbols are beginning to stick and I no longer need to make such frequent reference to the key supplied with the score whilst playing. We can, at this point, navigate a page of the score with only a few minutes' collective de-coding and negotiation before play, whereas in early sessions this process occupied nearly all rehearsal time for a single page. Furthermore, a good deal of tinkering and stripping down of the instrumental resources being employed by each player has occurred, with some degree of mutation between and within sessions, aimed at improved gestural intimacy, speed, and at conspicuous obviousness to each other. One primary concern is that to be quicker, we need to be able to spend less time searching for samples / processing options (in the cases of DMR and myself, both using Ableton Live software as a general canvas) or re-patching (in SW's case on his modular synthesiser). This has involved constraining the sound-worlds to a certain extent, and of arranging sound-production matters so that sound onsets (at the very least) are accompanied by determinable, correlated, bodily action.

For my part, I am using a miniature microphone (DPA-4061) running through a chain of filtering and distortion effects that can be adjusted using an external

MIDI controller. I also have a simple sampler patch of a basic synthetic tone, also via a chain of effects, which can be controlled on a standard MIDI keyboard, for those sections of the score calling for particular pitches. I am, however, using the microphone almost exclusively since having even two possible modes of interaction is hard going in combination with the demands of the score, and the microphone affords somewhat greater versatility.

We are, by this point, feeling sufficiently confident in our playing that we have arranged an informal performance for the following week at a nearby venue with an open-stage policy, and make documentary recordings in the rehearsal. Certainly, within the figurative space that we occupy whilst playing, it feels as if there is sufficient tension, dynamism and excitement to warrant sharing with an audience. However, when I listen to the recordings none of these seem to come through to anything like the same degree. For one thing, the music remains much slower than I was personally aspiring to; indeed, part of my interest in investigating the work was on the didactic basis that I thought it might help us, as electronic musicians, engage in quick-fire 'atomic' (Bailey, 1992) exchanges of sound. Furthermore, the recordings feel somewhat lumbering and mono-temporal with little variation in the overall 'mass' of the sound.

It occurs to me, albeit somewhat later, that one simple avenue we never explored was of players possibly sitting out for some duration after completing a system. This would have produced variations in mass by giving rise to duet and solo moments, as well as by increasing the possibilities of outright musical silence due to a player deliberately creating a deadlock by 'withholding' a new gesture with which to spark off further play.

Reflections

There are, again, three factors I wish to draw attention to in this engagement. The first concerns the conspicuous mutability of electronic instruments and—in common with *Background Noise Study*—how this affects any analytical distinction we may wish to make between instrument and score. The second and third concern the particular types of ambiguity encountered in *For 1, 2 or 3 People* and the status of recorded interpretations, and how these seem similar, but distinct from *Background Noise Study*.

First, in pursuing this encounter with *For 1, 2 or 3 People* with electronic / digital systems we confronted the mutability of such systems as we incrementally tailored our instruments to the demands of the piece. Moreover, we became aware of the ways in which these adjustments affected the particular

co-presence the piece orientates around. In the terms of John Bowers (2003), we were dealing with *contingent practical configurations*, which he takes to be redolent of improvised electronic musicking (see Section 1.3, p. 58, below for a fuller discussion of the work of Bowers). In these terms, we could be seen making adjustments to our respective contingent configurations so as to try and optimise a particular mode of interaction as demanded by our interpretation of Wolff's score.

As with the experiences of *Background Noise Study* above, it is hard to regard the score as being analytically distinct from the rest of the material resources that form our instruments. This is particularly the case given the degree to which these material resources were iteratively reconfigured so as to allow us to play the symbols more effectively. Also in common with the investigation of *Background Noise Study* was the issue of how to deal with ambiguities in the score. However, the questions here were of a somewhat different nature insofar as they did not concern aspects of technical implementation needed to produce a prescribed form. Rather, they lay in trying to interpret systems of symbols so as to understand *what* was desired. It is also not clear that these ambiguities are particularly accidental (Wolff, 1998; Thomas, 2010), rather than being an additional layer of playful indeterminacy. But, again, the interpretation of the symbols, and thus the eventual character of the musicking is affected by aspects (however hypothesised) that exceed the given materials.

Similarly, we took decisions about how to proceed based on suppositions about the imagined intent of the score. For instance, with samplers we could simply record and replay a co-player's gesture in order to get 'perfect' mimesis. However, we decided that this would be against the (conjectured) spirit of the piece, not to mention that we were revelling in the athleticism of trying to find our way quickly and adaptively to something resembling a particular sound (something that standard digital interfaces afford quite poorly). As such, we were exceeding the boundaries of the material as given, first by extrapolating from it into a presumed, culturally bound set of intentions on Wolff's part and, second, by allowing our sense of what was fun to feature in our interpretation.

The issue of how to relate to recordings of *For 1, 2 or 3 People* is somewhat different from *Background Noise Study* on two fronts. First, the piece admits performance on any kind of musical technology—which will yield highly variable results in any case—and does not specify any kind of particular formal element beyond the coordinating actions in the score. Second, there are a great

many more recordings available (the piece is, after all, almost 50 years old), including a number of performances freely available on YouTube and Vimeo, that exhibit variety in both instrumentation and results[4]. Given Wolff's apparent ambivalence on the matter (Thomas, 2010) is there any particular reason to take as especially authoritative versions in which he or his close associates (such as David Tudor) perform?

1.1.3 Stockhausen: Intuitive Musicking

This has been a peculiar performance; we (a small ensemble of SW, NM, SU and myself) have just limped somewhat apologetically to the end of Stockhausen's *Verbindung* from the collection of text scores *Aus den Sieben Tagen* (Stockhausen, 1970). At this point, we have been playing these pieces with a reasonable degree of confidence and musicality for around a year. Conversely, our immediately prior rendition of *Wellen* (from *Für Kommende Zeiten* (Stockhausen, 1976)) felt considerably more coherent and assured than any attempt we made in rehearsal.

We are performing publicly as an ensemble for the first time, in the setting of a fashionably all-white-and-shiny multi-arts space. The audience is quite different from what we might normally expect for our first public presentation, in that it is considerably larger and more varied in terms of proximity to the group's immediate community of practice. This enlarged audience is here because this concert has been enfolded somewhat opportunistically into the events of Edinburgh's International Science Festival.

In *Verbindung* players are called upon to produce 'rhythms' relating to a range of phenomena that vary between the simple and concrete (breathing, heartbeat) to the considerably more abstract (intuition, enlightenment, universe). These are first performed in a given order, albeit at each player's choice of pace, and then on an ad hoc basis.

There are a couple of factors that would tend to give particular shape to a performance of this text. The first section has a 'serial' nature (Bergstrøm-Nielsen, 2006), where the players perform each rhythm in the order given. This will tend to exhibit greater synchrony and coherence at the outset, given the more concrete and suggestive rhythms (especially breathing and heartbeat). As the categories become more abstract and as the phase differences due to different rates of progression become more apparent, a greater sense of heterogeneity often

[4]I have yet to find another all electronic version, but it would be surprising if ours were the only attempt made.

emerges. Our approach has also been informed to a certain degree by having watched on video a lecture by Stockhausen given at the ICA, London in 1971 (Stockhausen, [1971] 1989, 1971). In this the composer articulates more or less specific expectations for how some of these rhythms would be performed. He is particularly explicit about the interpretation of 'the rhythm of your thinking', stating that players should make short, impulsive gestures each time they are aware of their thoughts "changing direction". This tends to have particular results in that a certain interdependency between players is made audible as the actions of players trigger a change in thought for other players, and so forth.

Perhaps it is this relatively unmediated relationship to the situation of the players that has contributed to the particularly stark difference between the comfort of rehearsal and the profound discomfort of public performance; our rhythms are disrupted and, moreover, our expectations of each other's rhythmicity is disrupted. In short, we are unprepared for how profound an effect transplanting this performance from the safety of a rehearsal space to the exposure of stage will have: our bodies less comfortable, our heartbeats faster, our breathing more laboured, our thoughts more skittish, our intuition less inspired, our enlightenment more distant, and so on. For me, the performance of this piece feels laboured, contrived even, punctuated with almost embarrassed silences and a palpable lack of connection.

And this is how, unsurprisingly, the performance lodges in my memory. When I first review the recording, a few days later, nothing in it seemed to contradict this; I feel sheepish even listening to it (alone!). However, when I return to the recording some months later, it is wholly transformed. Rather than a group of people failing to connect, what I hear is a thoughtful, restrained (perhaps overly so), tasteful performance that succeeds in making creative use of the dynamic range available and in maintaining a degree of tension often difficult in improvised music.

Reflection

Again, there are themes to note here already seen in the accounts of *Background Noise Study* and *For 1, 2 or 3 People*, in terms of the particular relationship of the text to our musicking and—it will transpire—the mutability of instruments. I shall get to these by highlighting the particular dislocating role of public performance in this case.

Like *For 1, 2 or 3 People*, neither *Verbindung* nor *Wellen* specify any particular instrumentation. Moreover, there are no particular guidelines about

the number of players—they are 'for ensemble'[5]. The scores are also verbal, rather than symbolic, which presents another order of ambiguity distinct from those of either *For 1, 2 or 3 People* or *Background Noise Study.* In this case the ambiguity is explicit, insofar as it concerns the poetics of the verbal notation, and correspondingly the coping strategy of the group was different. Rather than having to worry that there was an intended meaning that we were missing, in this case the group was able to deal straightforwardly with the interpretation of the texts as matters for discussion. This is not to say, however, that such discussions were unaffected by any notion of what Stockhausen may, or may not, have meant; SW was in the midst of doing detailed research around Stockhausen's music, which gave him some authoritative status. We tended to go with his general guideline that we veer towards the most literal interpretations of instructions available, although of course there was scope for lengthy discussion about what the most literal interpretation might be.

Two particular disjunctures that arose as we orientated ourselves to public performance are of note, insofar as they had concrete effects on the character of the musicking beyond what was given by the score or the affordances of our putative instruments. The first concerns the introduction of microphones, and the second the moment of performance itself.

In preparing for the performance experience told us that it was worth considering the details of how to deal with stage layout and microphones (in part because both SW and I work as sound engineers). SW quite sensibly made sure that we had our final rehearsals plugged-in so that we could acclimatise and deal with unexpected problems ahead of time. The points I wish to highlight are, first, that this changed the way we played, but also that it *changed our instruments*, which now incorporated this electroacoustic extension, a point already noted by John Potter (1979).

This first aspect is quite uncontroversial insofar as it is confirmed widely by the experiences of musicians being put in front of microphones, and can be looked at through Jonathan Sterne's sophisticated theorisation of mediation as being something that always pushes back (Sterne, 2003). The second proposition, however, marks a point of continuity with the preceding case studies regarding the mutability and environmental coupling of instruments and that anticipates an important part of the argument of the following chapter. Not only did our playing change straightforwardly, such as by taking advantage of

[5]Some of pieces the pieces in *Aus den Sieben Tagen* and *Für Kommende Zeiten* are more specific.

the extra dynamic range that microphone technique can afford, but each of us ended up augmenting or otherwise changing our orientation to our instrument in significant ways.

SW, for example, both took a feed from NM's viola to process, but also added a set of closed-mic'ed singing bowls to his setup; NM introduced a new textural element by incorporating one of her baby's toys (which would have been wholly inaudible under unplugged circumstances). SU's relationship to the piano frame became an increasingly whole-body affair; she would lie across it and explore the new scope for articulating the small clicks and pings that the microphones could pick up, as well as introducing moments of intense ferocity to her playing that I had not seen from her ever before.

In this ensemble, in distinction from the accounts so far, I was not in fact playing electronics, but was using a bowed cardboard box that I had been exploring as I worked on ***Cardboard Cutout***, one of the portfolio pieces. I was able to reincorporate techniques that I had already explored with the box-microphone system, such as exploiting proximity effect to produce improbably large sub-bass textures. Also, I found my own source of smaller sounds in textures from rubbing the bow hair and in small, slightly cartoonish percussive events from plucking the whole bow hair, both very close to the microphone. In this sense, then, the resources we took into performance were not the same as the resources we had always rehearsed on. Also, and more obviously, there was a series of smaller adjustments to be made *in situ*, in response to the amount of gain practically available from the system, our spatial orientation, the needs of our fellow performers and so forth.

Second, as noted in the account above, the nature of the performance itself was affected by the social conditions in which it occurred. Whilst none of us, by this point, were by any means novice performers, this was the first outing of any kind with this particular group, doing this material, and we might more normally have expected to try it out first on a home crowd. The time it took for us (well, me, at least) to shake off self-consciousness about what we were doing on stage was affected by playing to a full, largely non-specialist audience at an event that had, by dint of its absorption into the science festival, become part of a wider display of cultural capital by the university. Moreover, the tendrils of the world offstage contributed substantively to the way our musicking formed; I was feeling stressed and grumpy at having become unwilling technical and stage manager for the whole weekend of concerts. Another of our number, in particular, was especially tired and feeling

somewhat apprehensive at their first public performance for some while. One musical consequence of this was that my playing was unsettled and I found myself trying quite conspicuously to make extra room for our nervous member in a way that was quite possibly counter-productive.

This brings us finally to the interpretative status of recordings of this work; first, of our effort in particular, and—as with the above case studies—more generally. The quite radical disjuncture noted above between the initial assessment of the recording (burdened with uncomfortable memories of the performance) and later listening (when it sounded fine) raises a number of interesting points about the status of recordings, of performances in particular, as artefacts in their own right. I pick this up again in Chapter 5, but for the moment we should note that, given the discrepancy, there remains something of an open question about how we evaluate our own performances. In the more general sense, as with the case studies above, it is worth considering the possible role that extant recordings may have in establishing a canonical interpretation. In this case, despite *Verbindung* and *Wellen* being of a similar age to *For 1, 2 or 3 People*, there are considerably fewer published recordings, or performances documented on the internet than of Wolff's piece. On the one hand, this makes the question of canonicity less ambiguous, given that there are recordings of both pieces with the composer performing in the group, and also on the composer's record label (Stockhausen, 1996, 2005).

On the other hand, interesting questions present themselves about *why* it might be that there are fewer published performances of Stockhausen's text pieces. Reasonably comparable historical circumstances seem to apply both to Stockhausen's intuitive music scores and to *For 1, 2 or 3 People*. They are of similar ages, the scores are available through major mainstream publishers[6], and both Stockhausen and Wolff are relatively famous composers (Stockhausen probably more so). Furthermore, the intuitive music scores would seem to offer fewer immediate barriers to a player, given the absence of a complex and idiosyncratic notation.

There are, of course, all kinds of possible explanation, which is, in part, my point. It may be that Stockhausen or his publisher were more protective of their copyright than Wolff; it may be that Stockhausen's reputation as a more authoritarian figure than Wolff (however deserved or otherwise) has made his

[6] *For 1, 2 or 3 People* is published by Peters (Wolff, 1964) and *Aus den Sieben Tagen* by Universal (Stockhausen, 1970), although *Für Kommende Zeiten* is published by Stockhausen Verlag (Stockhausen, 1976)

Intuitive Music pieces less appealing to improvising performers. The salient feature to emphasise is how this has a bearing on the eventual performance of a piece of music, in that the status and quantity of recordings are bound up with other sub-cultural narratives (for instance, Stockhausen as authoritarian maestro).

1.2 Case Studies II: Improvising

1.2.1 Laptopping

I have been playing music on laptops with DMR for some months, when we team up with JR. Up to this point, a salient feature of our playing has been that it was for no other purpose than as a way of passing social time with each other, of getting to know one another. This has yielded a quite unhurried approach, as we have felt free to make music with no particular reference to how it might work on stage or acousmatically; we have been free to experiment with various strategies for creating space and cohesion with reference only to how enjoyable the results are for us. DMR has also been playing socially with JR, but our first collective encounter happens in the context of an impromptu performance at Edinburgh's Forest Café that goes well enough to prompt us into making a more permanent trio. One thing we decide at the outset is that this will be a 'straight' laptop trio, insofar as we follow the path of least technological resistance and simply use Ableton Live and standard MIDI controllers. The motivation for this is partly pragmatic and partly perverse. Pragmatically, we don't have to invest time in trying to interface complex and possibly fragile bespoke patches and programs, we can just sit down and see what we can make a standard interface do. Perversely, we can come at the problematics of laptop music—communication, spaciousness, scrutability, theatricality—by embracing them. Given the success of our first, impromptu performance, we also immediately set about taking on more gigs.

This re-orientation towards performance, and the changed shape of the group have quite profound effects on the way we music. Previously, DMR and I had made music which was deeply unhurried—our sets would run to an hour or more, and would slip laconically into and out of beat-led material. The pace and intensity with three of us is somewhat greater, and a sense of pulse is almost ubiquitous; both DMR and JR have developed techniques of constructing beats from raw materials, much as one would with step sequencers (so that one or both of them

may be doing this at any given point)[7]. We continue a strand DMR and I had been investigating with tactical uses of each other's signal flows, especially making use of gates to create space and a sense of coordination (though perhaps more of a simulation in the Baudrillardian sense). The addition of a person makes this technique both more and less effective; on the one hand, the palette of potential outcomes is enriched, as there are more available permutations of X gating from Y (and, of course, a kind of deadlock can occur, which strikes me as a potentially rich seam for compositional strategy). On the other hand, the complexity of setting up the interconnections in the first place, and negotiating them at play-time is considerably increased—it is palpably more difficult to keep track of the key signals, which are liable to disappear without warning as a player withdraws. This raises the issue that the potential confusion of agency is much greater now with three players, but still only a single pair of loudspeakers between us.

A combination of the need to negotiate these areas of confusion, and a changed orientation towards public performance seems to lie behind some changes in our playing that gradually take form. Most strikingly, each of us starts to inhabit a considerably more delineated sonic neck of the woods, and intriguingly this takes place without any real discussion, although—as soon as it is commented on—it begins to take on the feel of a policy more than a pragmatic tactic. This territorialisation relates not only to the kinds of source material we may introduce, but also to the kinds of transformation we are liable to perform. For instance, I start making greater use of an external microphone, initially as a mechanism for punctuating my sonic flow (again with the gates), and I also start to draw more heavily on sampled vocal material (songs, films, cartoons), as well as introducing some of my own sub-Phil Minton vocalising. My use of effects tends to be orientated towards what JR describes as "dirty, dusty and filthy"' as I create jagged textures through extreme gate settings and idiosyncratic uses of distortion. DMR, on the other hand, makes use of more atomic material—single drum strikes, for instance—and cleaner transformations, such as very narrow bandwidth channel vocoding, as well as long reverbs and delays, which sometimes veer uncomfortably close to the new age. JR's sound world tends to draw on a preference for 1990s glitch, with short bursts of pure tones, often at extreme frequencies, and signature transformations such as very tightly iterated loops, pops and clicks.

As such, a sort of dialectic comes into operation between the sonic and gestural division of labour one might associate with an instrumental ensemble, and

[7] Obversely, my approach to beat-making has tended to rely somewhat more on serendipity, by layering and editing sampled material

ambiguous agency afforded by being able to electively couple our playing environments via the medium of signal flows. Challenges remain, however. Whilst we are apt to congratulate ourselves and accept congratulations from audience members on the *quality of our listening*, this does not seem to be sufficient for providing a quality of coordination: we can evidently attend to the sonic flow, and pounce with reasonable agility on gaps as they present themselves (although these are easier to fill than to participate in) or adjust the character of our actions sympathetically with the prevailing sonic flow, there are issues of attentiveness that remain.

Bluntly put, there are frequent instances where the material of the other two players may just as well be additional streams on the first player's machine, for all that attention is almost wholly directed into the symbolic space of the software rather than at achieving gestural coordination with one's fellow human players. Similarly, problems DMR and I encountered with MIDI clock sharing persist: the tactus of play is either locked to a 'master' clock, or completely unfettered, and in the former case this means that temporal change remains something that is enforced upon, rather than negotiated between players.

Reflections

This on-going work with DMR and JR highlights a number of issues that seem to crop up in improvising more generally, but in live electronics in particular. First, the way that the divisions of labour have formed in this trio have been particularly pleasing in that they have arisen largely informally through playing and negotiating in the moment, rather than from more overt directedness. This affords some broad sense—among ourselves—of what each co-player may be more or less likely to do next, without foreclosing the possibility of overlap, surprise, subversion etc.

Some sort of approach to devising fairly stable musical roles within the group could be argued to be more necessary in the case of a laptop ensemble than with, say, a rock group or string quartet because we appear, ostensibly, to all be playing the same instrument. From our perspective as players, this is not the case at all, of course; even if we are using the same software the choice of external control devices, sampled material, software options, signal processors and the ways in which these are interconnected have a profound effect on what constitutes our instrument. Moreover, given that these particular interconnections are dynamic, the instruments themselves are highly mutable; we are not necessarily in a position to identify who is doing what by

stable association with a particular sound type. As such, having some broad behaviours around which we can play, rather than stay rooted in, can help resolve moments of confusion.

From the perspective of the audience, on the other hand, the degree of instrumental distinction will be much less apparent. Often the only equipment they are able to see is the backs of laptops, which are basically identical and uninformative. This can easily alienate an audience, who cannot join the music as *an inter-personal exchange*, but instead are confronted with a complete, fused sonority that emerges from a unified location (the front of house loudspeakers). Bodily-gestural territories that are correlated with our sounds can offer clarity in this respect; again, there is no particular reason to anchor ourselves doggedly to these, rather, following Bowers (2003), we can make them available as regions in which to play (see Section 1.3 below, p. 58).

Finally, the range of issues around timing described in the final paragraph of the account above appear, on the face of it, to be distinctive to electronic musicking. Most evident—aside from the technical issues of how to arrange coordination and interesting temporal interrelationships—is the musical issue of how easy it is to over-play in this kind of set up. One aspect of this is that because a good deal of the interaction with sequencing-type interfaces involves the launching of processes which then require no further physical effort to maintain (but would, conversely, require some small effort to halt), it can be the case that electronic sets occur where everybody is making some kind of sonic contribution all the time. However, as much as this might make it seem like a distinctly electronic issue, the end result, which can manifest as a kind of lack of attention to the *aggregate dramaturgy* of a collective improvisation, has been as apt to occur with acoustic instrumentalists as well (see Section 1.2.3, p. 53, below). The distinction, then, is one of degree; the particular affordance of electronics to keep launching stream upon stream affords tremendous dynamic and textural range, but this, of course, needs to be consciously taken advantage of, which means that a combination of technical and socio-musical tactics needs to be explored. For instance, some way of selectively, but musically, halting streams needs to be found—how to bring five out of seven channels to a synchronous stop in a mouse-based environment?—*as well as* some agreement reached between players that (at least in performance) people will be prepared to sit out for some of the time, in the interests of a more varied set.

1.2.2 LLEAPP: Over-complicating matters

A group of three of us have been thrown together as part of the inaugural 'Live Laboratory for Experimental Audio Performance Practice' (LLEAPP), a series of practice-led symposia of which I am a co-organiser. As this is the first time we have tried this, no better scheme for organising groupings of players than drawing names out of a hat had been arrived at between the participating postgraduate students. I have ended up in a group with JR, with whom I already have a musical relationship, and JT, an oboe-playing visitor. Each grouping will work intensively for two days towards a public performance on the final evening. After initial discussion, our approach has been to arrange things so that JT and I play acoustically (I am playing saxophone) into a pre-existing, generative Max patch of mine, whilst JR performs using his extensive library of samples and a bespoke patch controlled by a Wacom tablet. This makes a potentially interesting interplay of competence-incompetence between JT's virtuosic oboe playing and my wretched horn playing. Also, by configuring ourselves in a way that is very different to our normal laptop partnership, it makes it less likely that JR and I will be able to slip into co-musical habit at JT's expense.

We begin by improvising, and everything is going very promisingly. The patch that JT and I are connected to produces bubbling, swirling textures based on live-sampling of its inputs, and a nest of internal feedback paths. By gating it to some extent from the microphone inputs, we are able to ensure that it is not a constant, and thus boring, presence. JT establishes a sound-world of squeaks, squawks, whispers, taps and rasps; I occasionally interject with some strangled, if somewhat poorly controlled, interjections from the mouthpiece and crook of my alto horn, mostly with the mouthpiece upside down, so that I can bite into the reed and produce unstable, beating tones always on the verge of collapse. JR's sound library does indeed complement this well. In contrast to the other, quite dirty high-pitched noises that are also quite gesturally atomic, JR is able to produce more drawn out, lush material, and to provide a much needed low-frequency anchor, as well as joining in the gestural punctuation with stabs on a pen-tablet that triggers samples. The playing is very easy-going and fluid considering the novelty of the relationships, but we are all still being a bit polite; the music is pleasant, but never shocking and everybody is cheerfully agreeing with everybody else. An immediately apparent difference when playing with an instrumentalist is that they get physically tired, so, in deference to JT's chops, we cease while things are going well and join the rest of the workshop at the pub.

The following day is characterised by a series of moves that over-complicate matters. We start off by continuing to improvise for a while. I have augmented my set-up with a volume pedal on the outputs of my laptop, so that the textures can be made completely absent at certain points. Following up on an earlier, hazily expressed commitment to 'constraints', JR suggests that we start attempting to catalogue different areas of the emerging sound-world in order that we might sketch out some sort of composition to guide our final performance. Several more bouts of improvisation, interspersed by discussion of what sorts of categorisations are possible. I notice that whilst I am tending to think more about the kinds of relationships between players in locating areas of the sound world, JR is tending more to reflexive descriptions of the sounds-themselves. Having made a small list of these different categories, JR suggests an Earle Brown-esque approach; we each devise for ourselves a performance score that connects up a number of 'systems' based on these descriptive categories, and a limited number of ways in which we can move between them. We do this, and play through the results a few times. The playing is decidedly less fluent, as we get use to the additional cognitive load of attending to the score as well as each other. We express concern that the score is actually interfering with coherence, as there is no guarantee that players might congregate, or be able to, on a common category, and it is also difficult to know where we are.

We make an addition to the score, in the form of an agreed synchronisation point, expressed in clock-time-since-starting, characterised by a quick-fire exchange of squawks between all players; JR dubs this 'penguins'. We experiment with this for a while. The synchronisation point certainly helps with locating ourselves, but often goes on too long once we have hit the comfort of knowing where we are, and much of the lead-up and run-down to and from this point feels too much like they are merely preparatory. I worry to the rest of the group that we are losing the richness of our interrelationships in deference to the score, and consequently listening less attentively to each other. We break for sustenance.

Fed and watered, JR submits an idea to respond to my concern about interrelationships. He proposes an embellishment to the score that appropriates aspects of Smalley's spectromorphological framework, specifically the behavioural archetypes (Smalley, 1997, p. 119) as behavioural propositions for gestural interplay. I am torn; on the one hand, I think it is a terrible idea, particularly as it seems to me that adding further to the score would only exacerbate the problems that concern me and, furthermore, the distinctions on offer seem to me to be somewhat blunt and distanced from the situated, emotive grain of the relationships that I

think has diminished. On the other hand, it *is* an intriguing idea insofar as it provides a compositional mechanism grounded in players' responses to each other that could, plausibly, make for interesting musicking, and I am less than eager to interfere with the generally convivial atmosphere by not agreeing to give it a whirl. To contrast with the indeterminate nature of the system-based component of the score, each player produces their own linear flow of these behaviours, without consultation with the others, to describe progress through the piece. As such, the possibility exists that players could be pursuing conflicting behaviours at any given time, which seems potentially appealing. The going is difficult; the score now, predictably, imposes an even greater cognitive burden, but the consensus is that it provides something that can be *worked upon*, that if we were to develop enough fluency, we would be able to direct greater amounts of attention back to each other's detailed flow whilst having a rich framework to structure action. We pause to attend a seminar with the rest of the workshop and fellow postgraduates from Edinburgh University.

The following day, we have only the morning to rehearse before we all depart for the venue of the final concert to start setting up. I am still ambivalent about our capacity to become fluent enough with our score, but feel that we are committed. I have a surprise, also; JR, who was apparently feeling distanced from the action by not having a directly physical means of sound making, has turned up equipped with a Xaphoon. I am not delighted with the results; JR's attention is now split between his sample production and blowing on this thing, to the detriment of the former, and the sound-world has lost the clarity I valued to give way to a collision of predominantly unskilled reed noises, with some now confusing electronics in accompaniment. Somewhat fatalistically, I let this go: it is not as clear to me at this point as it will be in retrospect that what I want is to ditch the score and extra instruments and return instead to what I felt was the considerably better musicking we started with, and it is hard to suggest that the Xaphoon be discarded given JR's enthusiasm for the idea. We are here to learn, I remind myself, and fortunately I am generally quite philosophical about the possibility of a gig being awful. We practise hard, and it does feel like we are making progress in coming to terms with the new sound world and the difficult score. The main challenge, now that there are more sources of less differentiated sound, is in preserving space for each other. I feel JR is overplaying his Xaphoon, but wonder whether I am just being territorial about sharing my status as less-than-competent horn-man.

The performance goes reasonably well, although (like all the other groups) we had slightly less material than the time allotted to it warranted. It becomes

retrospectively obvious that we organisers should have been more insistent than we were about getting all the groups together for peer demonstrations as we went along. As it was, we deferred to the wish of more technically embroiled groups to keep working—one group had not been in a position to start practising in earnest until the final morning. The sound check passes without extraordinary incident, besides the normal problems of suddenly buzzing pickups and temperamental computers. I do, however, find that I am playing much more loudly than when in the rehearsal room. I reason that this is partly environmental, in that I feel inclined to blow harder in a bigger space, and is perhaps partly due to frustration and nervous energy. We manage, in performance, to locate ourselves in the score, but only just. The lack of differentiation between the sound sources interferes, and JR is now doing considerably less work on the laptop, which had been serving a useful purpose of binding us together somewhat. Even if schematically correct, the music we make on stage is by no means the same as what we had rehearsed—now at the mercy of a front-of-house sound engineer and foldback monitoring, what we produce is none-too-expert horn-based free improvisation with coincidental, strangely balanced, and maybe even purposeless electronics, at least from a listener's point of view.

Reflections

In this episode we see reinforced a number of ideas from the accounts given in Sections 1.1.2, p. 37, and 1.1.3, p. 40. Again, we see how profound an effect the design of performance instructions and scores can have on the musical action that emerges, the potential dislocation that arises when the group reorientates itself towards performance, and the various ways in which musicking is bound up with social interactions.

A primary difference in this case, however, is that rather than approaching the score as a pre-existing artefact to be interpreted, here the notation was something devised by us in order to encapsulate and structure the musical relationships that we had been working through. As such, some slightly different observations can be made. Whilst we can argue again that the notation becomes part of the musical interface, to the extent that it demands attention, negotiation and *learning*, we were also able to witness, in small scale, the transformation of our score from something that was attempting to serve as a way of mapping an established musical co-practice, to something that assumed a generative logic of its own.

Whether or not we wish to make a value judgement about this is a different matter, of course. It is true in this instance that the notation we devised was considerably more burdensome than we could cope with in the brief time available, but this does not invalidate either the principle or the particular attempt. Given more time to learn, and perhaps enhance, the notational idea, it is quite probable that we would have been able to find a way to make better music with it. Additionally, the whole experience yields an important experiential benchmark for what and how much one can expect to achieve with *ad hoc* notational schemes.

Interesting questions are also raised by the decision to take this decidedly more fragile scheme into performance, rather than retreat to the relative safety of one of the formations that seemed to be working better. First, it is apparent that the imperative of orientating ourselves towards a public presentation could be argued to be in tension with the priorities we started off with, and that the practical contingencies of performance (poor monitoring in this case) had a palpable impact on how we were able to play.

Second, it can also be argued that our social priorities—in not offering more forthright criticism for fear of hurting feelings—are hard to separate out from the eventual performed result. Even if, for instance, we were to press ahead with the final version of our score in performance, it is telling that we ended up playing longer than the material supported; both the score and a certain degree of emergent fixation on the fact of performance seemed, in the end, to ossify musical instincts that would, under more improvised conditions, have been expected to cope creatively with whatever problems we encountered.

1.2.3 EdImpro: Cooks vs Broth

EdImpro is a medium-scale improvising ensemble with a floating membership drawn, particularly, from Edinburgh University, but also from Edinburgh's wider musical community. At the time of writing it has been having bi-weekly rehearsals for around four years, featuring between two to fourteen players, usually around nine. The varying membership makes for varying instrumentation, but on the whole acoustic instrumentalists are dominant, although there are sometimes as many as three electronics players. My participation has been varied over the years, but I am currently a member of a newly-instituted 'core' ensemble, devised in order to try and provide some level of consistency to rehearsal attendance and concert participation.

Describing what it *feels* like to play in this ensemble is challenging, not least because of the time span and the fluid configuration of co-players, but also because I have not been wholly consistent in the instrumental resources I have used. Indeed, on some occasions I have eschewed electronics entirely, sometimes bringing an alto saxophone (which I can not play in any normatively recognised sense) or just using my voice. However, examining the motivations for these tactical manoeuvres of mine provides a way in. Whilst there has been sometimes a purely pragmatic component to my selected instrumentation—for instance, that I had been unsure of being able to make a practice, and had opted not to speculatively lug all my equipment into town—my choices of what to bring, and what I did with it are influenced by the experiences of my on-going participation with electronics.

Primarily, what I experience whilst trying to participate with electronics is a sense of dislocation, of distance from the rest of the ensemble. Although this is to some extent explicable in material terms—for instance by my spatial relationship to the loudspeakers—it is not wholly so. Part of the sense of distance is *idiomatic*; this is my first sustained attempt at playing electronics in a group mostly comprising acoustic instrumentalists, and it is sometimes difficult for any of us to be co-intelligible.

The difficulty does not lie with a lack of familiarity with electronics *per se* on the part of the instrumentalists, as a number of them either play directly or alongside electronics in their other activities. Rather, it seems as though sessions function as a sort of negotiation between players, and that the instrumentalists, unsurprisingly, can gather around not only the common technical affordances of their instruments (being pitched, tempered etc.) but also *idiomatically* around loci of their musical histories in ways that are prone to leave what feels like little room for a sound-based[8] approach. Put more crudely, there is a tendency for the instrumentalists to cluster around a 'safe' shared generic territory, be that be-bop, atonality, or idiomatically European free improvisation. This tendency appears to be correlated to the overall size of the ensemble, suggesting that the larger the group, the greater the uncertainty between players, and the more inviting the refuge of a shared basis.

Of course, an option open to me would be to simply modify my setup so that I could participate with such clustering in a note-based way; I could use my laptop as an equal-tempered, absolute-pitched synthesiser or sample playback device and play, say, a MIDI keyboard (which I use anyway, but not normally with much semblance of piano-ness). However, I am unwilling to do this. Perhaps I am too

[8] In terms of the sound-based / note-based distinction proposed by Landy (2007)

stubborn, but my position is that sound-based musicking is where my practice takes place, and that if I had shown any inclination to become more competent in note-based musicking, then I would have by now.

I reason that this could be a problem of *sense-making*: my ability to make sense of proceedings is framed by my capacity to *act sensibly*[9]. If the instrumentalists have gathered around some idiomatic locus that is particularly obvious, and one that is historically distal from sound-based practices, such as bebop, I can find it hard to make a contribution which might seem contextually sensible to my co-players, beyond merely trying to communicate my difficulty either passively—by ceasing to play, and maybe sulking a bit—or actively, by doing something conspicuously *un*sensible, egregious even, in order to encourage (or maybe *force*) a contextual shift.

This latter tactic can be pursued with greater or lesser nuance, bearing in mind that less nuanced tends to be more aggressive. A less nuanced approach simply involves *interrupting* proceedings in some manner. For instance, in a moment of frustration with what seemed to me to be an overly long and somewhat inward-looking jazz excursion, at one point I simply started playing the theme music from the television show *Cheers*, very loudly. Whilst this approach could hardly be characterised as productive, insofar as it quite deliberately disrupted the moment, it was (fortunately) understood as being funny by my co-players, and served to diffuse tension. More subtly, I can simply treat periods of idiomatic play as an invitation to play genre games, which the laptop (appropriately stocked with samples) is more readily suited for than for direct note-by-note play. This tactic can work quite well, as it offers somewhere for fellow players to go, a way to respond.

More generally, however, the most challenging aspect to playing with a large number of instrumentalists, who will be variably able / inclined to make sense of the electronic contribution, lies in the temporality of my contributions. From the point of view of gestural legibility, relatively large time-scale gestures enacted with some degree of theatricality (as with Wolff) seem to afford the greatest clarity. However, within such gestures it proves quite challenging to provide enough nuance in order that I may generate movement with which to interact, rather than a kind of punctuated sonic wallpaper on top of which the instrumental activities do their thing. In the absence of such scope for intra-gestural nuance, I have to rely to a greater extent than the instrumental players on establishing eye contact to signify that I am attempting to play closely with somebody.

[9]Which does not rule out playfully...

An ongoing challenge to all members of this somewhat motley group is to tackle what it is that they think improvisation might be *for*; the work is differentiated by the fact that the group is the only one described in this chapter where improvisation is an explicit and central focus, rather than a convenient framework for musicking, and that the group, fluid as it is, has no particular social basis for its composition. This, unsurprisingly, leads to a great deal of talking about improvisation, and differing expectations of what it is, and what to expect of it. One view is that, even in this kind of non-concert setting, the value of what has transpired can be assessed in terms of *the product*, that is by some properties of the overall sonority (formal characteristics, timbral variety etc.). Another is far more concerned with the *process*, that is, how effectively players were felt to communicate, engage and interact over the course of playing, trusting to some extent that doing these things better will help produce a 'better' gestalt, but also arguing that concerns about product are altogether less pressing in the absence of an audience.

Overall, the on-going participation with EdImpro is by far the most interactionally challenging of the musical activities described in this chapter, given the many challenges of integrating the peculiarities of live electronics into such a large and disjointed ensemble and the various different aesthetic stances brought by participants.

Reflections

There are two broad ideas I wish to pull out from this account. The first is that aesthetic tensions arise between improvising that is ostensibly 'free', on the one hand, and is idiomatic, on the other. Some players in EdImpro feel that reference to existing styles dilutes the improvisation and that the aim should rather be towards a mode of invention that arises totally in the moment and eschews anything that might be regarded as habit.

This position seems more than a little idealistic and logically somewhat implausible. It is not clear what would stop the sound of a group of people working out a form wholly in the moment as being characteristic enough to constitute its own idiomatic commitment, for instance the kind of 'searching and reflecting' we might associate with John Stevens (Stevens, [1985] 2007) or the more 'laminal' sound of AMM (Bailey, 1992).

Although attempting to play wholly *ex nihilo* (to the limited extent that this is practically possible) makes for an engaging and satisfying type of mu-

sical game[10], there does not seem to be any compelling reason to give it aesthetic primacy over any other type of improvising game. Moreover, wholehearted search for—and reflection upon—new personal techniques is not always accompanied by sustained attentiveness to co-players and the collective development of a form; at its worst, an unfocused simultaneity can emerge in place of focused co-action, marked by speculative, untimely and tentative noodling. There would seem to be good grounds to suspect that an inflexible commitment to total invention in every aspect of the group's musicking makes achieving a mutually satisfying result very challenging indeed.

Historical tropes bound up in this position should be subjected to critical scrutiny. Most obviously, the position would seem to share with the broader post-War avant-garde an anxiety for novelty and almost-hostility towards tradition, as well as a somewhat romantic commitment to the heroism of *ex nihilo* invention. However, it is hard to see how such operating assumptions could sit easily with improvising's implied—sometimes explicit—commitment to radical musical democracy. Just as idiomatic playing can be inimical to inclusive improvising if it leads to a breakdown in attentiveness and responsiveness that narrows the space in which co-players can contribute, an established hostility towards any idiomacy can just serve as a stifling prohibition that leaves players, especially novices, with nowhere to start for fear of committing a musical *faux pas*. Such commitments can also reflect the historical positioning of practices and sub-cultures; for instance, George Lewis (1996) is critical of the disavowal of 'jazz' by European improvisers as a revisionist act of positioning that participates in the 'erasure' of the cultural contribution of black, particularly African-American, artists. If a commitment to non-idiomatic playing is going to serve as a coded way of excluding 'jazz' practices as too idiomatic, whilst other idioms are tacitly allowed (e.g. atonality), then the idea should surely be subjected to critical scrutiny where it is encountered.

The second broad issue is that tensions over the gestural legibility of players of electronics can arise between the instrumental and electronic musicians. Whilst this issue has been discussed quite widely in terms of audience reception (d'Escriván, 2006; Emmerson, 2007), it has received less attention as a factor in the microsocial and aesthetic negotiation between players, with John Bowers providing an honourable exception (Bowers, 2003). One component of this is obviously practical, insofar as some of the instrumentalists in EdImpro said that they find anticipating or differentiating between the actions of electronics

[10]I'm using 'game' here in a fairly broad sense, following Shusterman (2002)

players considerably more difficult when unambiguous bodily action is missing. Another component is aesthetic, as some of the acoustic instrumentalists state that they find it boring when the electronics tends towards the textural, rather than gestural (see Schafer, [1977] 1994; Smalley, 1997, for different approaches to this dualism).

Part of this may be explicable in terms of differing musical backgrounds; much electronic music does give more immediate aesthetic priority to the exploration and development of textures, and to an extent this can be understood as arising from the affordances of the technologies involved. However, one could also understand this as dissatisfaction with the kinds of roles that can emerge, and entrench, as the acoustic instruments can be put in the position of having to play over a defining background over which they have no particular say, or even an easy way of participating with, whilst the electronics players all sit back vamping. This entails both a set of social-musical relations (soloists and backing band) as well as a foreshortening of the potential sonic range of the ensemble.

1.3 Threads

A number of repeating themes has arisen over the course of the accounts above. We have seen repeatedly how boundaries between analytically distinguishable categories—instruments, scores, recorded artefacts, ideas and social configurations—have co-mingled in practice to have substantive effects on the conduct of musical activity. By examining a series of miniature case studies from a first-person perspective, covering different particular areas in the complex space between the idealised extremes of totally composed or totally improvised musicking, my purpose is to bring into relief some specific territories that are explored throughout the remainder of the thesis and its accompanying practical work, on the basis of those which seem most critical to the area of live electronics *as I would like to practise it.*

One particular precursor for the approach I have taken here can be found in the work of John Bowers (2003). Bowers identifies a number of distinct territories that his particular research in electroacoustic improvisation explored, which share—indeed have helped shape—a number of my foundational concerns. Before going on to detail my own distinct concerns, I shall outline the territories Bowers proposed as they offer us some helpful vectors of broad concern as well as a useful starting vocabulary:

Contingency An issue of overarching importance for Bowers in his electroacoustic improvising is a receptive stance towards '*contingent practical configurations* which interrelate technology, musical materials and form, performance practice, the specifics of setting and occasion, and different understandings of improvisation' (pp. 42–3, emphasis in original). For Bowers, a central preoccupation of his improvising is that it involves, and can be witnessed to involve, coping musically with such contingency, that he then proceeds to map along the following lines.

Sociality Bowers notes how one source of contingency is the relative positioning of players and the different roles they adopt (possibly as a consequence of their positioning), and stresses that this is of palpable significance for musical outcomes. Such a proposition is, of course, not uncommon particularly within ethnomusicology and related endeavours, and we could relate the particular concern with what Bowers calls 'local socialities' (p. 45) as dealing with those aspects of 'the social' in music most readily observable through practice research (see Born, 2010a, for a broad survey of the different social levels at work in music).

Engagement and Interactivity Just as our disposition towards each other affects our musicking, so Bowers is concerned with the significance of our disposition towards our equipment as a domain within which to play. In this context Bowers makes two significant propositions. First, that instead of orientating his practice around the performance of one particular mode of interaction[11], Bowers takes a pragmatic approach that encompasses different forms and is interested in 'the public display of this variation and how one can negotiate transitions within it' (Bowers, 2003, p. 46). Second, Bowers makes the very important observation that the affordances of particular equipment arise from the context in which it is encountered, such that issues like its spatial arrangement are of consequence to musical outcomes and their legibility, leading Bowers to speak in terms of a 'performance ecology'(p. 47, later taken up and expanded by Simon Waters, 2007); I return to these ideas in more detail in the following chapter.

Musical Materials Bowers provides a similarly pragmatic account of the ways in which different musical materials may be taken *to signify* in his

[11] for instance, an instrumental energetic pulse→sound mode, or a more delegated autonomous system

> improvising practice by insisting that this, too, is a contingent matter that arises in practice rather than as the product of allegiance to a preferred mode of listening. In this sense one can see the extent to which post-Schaefferian discourses of listening have evidently loomed in Bowers's community of practice (as they have in mine), thus the need to confront the 'bracketing out' of reduced listening (Emmerson, 2007). Whilst stressing that the way in which a particular piece of material may be taken up is not knowable in advance, Bowers is constructively careful not to reject out of hand these discourses of listening, but instead makes some intriguing suggestions about how some of these theories might afford being recast into the interactional domain of improvised performance.

We can see how these concerns reveal themselves in the examples above. In each case, dealing with practical contingencies is clearly integral to the musical activity, from the explicit 'structural coupling' built in to Di Scipio's *Audible Ecosystemic Interface* and the efforts to replicate the system satisfactorily, to the social contingencies of performance made particularly apparent in the Stockhausen performance. In all cases the especially contingent nature of electronic equipment as a means for musicking is apparent, as new instrumental affordances emerge with the introduction of microphones (Stockhausen), 'performance ecologies' are refined and adjusted so as to accommodate the demands of a score (Wolff) or the challenges of playing in larger groups (EdImpro), and as scores themselves impact the social and interactional dynamic of a group (LLEAPP). The contingency of musical materials makes itself most apparent in the ways in which material can be re-sampled and transformed between players (Laptopping), or in the contended significance of different kinds of stylistic tropes and other aesthetic markers in group improvisation (EdImpro).

1.4 Territories

In introducing a consideration of composing to the ideas of Bowers I am seeking to develop some complementary territories that explore negotiations between the degree and manner of specification of musical aspects in advance, and the working out of these aspects in the moments of performance. For Bowers this took place, to an extent, via the development of some specific performance

patches (also documented in Bowers, 2003) and, as we have seen above, there is certainly an ambiguity about the distinction between *composition* and *instrument* that is conspicuous with electronic technologies. In a sense, I am extending this by enlarging the scope from a personalised mediation (an instrument in the conventional sense) to some set of mediations and specifications that have a more direct bearing on the activities of all players, by channelling the unfurling of musical duration in ways additional to the in-the-moment sense-making activities of improvised conduct. These specifications and channels are, however, still presented as an 'in-the-box' computer algorithm (to the extent that this is practicable in each case), so that the ambiguity between composition and collective instrument is quite deliberately maintained.

There are a number of related rationales for taking this particular approach. First, to better afford certain types of musical co-action that seem to be more difficult in an improvised, particularly electronic, setting; these can be collectively regarded as aspects concerning the management of dramaturgy (Landy, 2007), such as moments of synchrony, the variance of density, the definiteness of beginnings and endings, and the transitions between sections. Second, the preference for embodying these compositional ideas within algorithms arises (at least in part) due to matters of ergonomics and reception—for instance, I wish to minimise the amount of screen gazing, and have no desire to replace this with score gazing. Third is in an interest in some degree of coupling between musical means and materials, and the local environment of performance (following Di Scpio). Fourth is a preference for schemes with a degree of adaptivity that allows players to go 'off-piste' in a rewarding way; for instance, a preference for resistance, rather than failure on the part of the mediating algorithm if things do not go as expected. Finally in those pieces that are collective, I wish to preserve the already extant practices of co-players rather than present them with a whole new 'instrument' to get to grips with.

These particular tactical commitments can be related, in turn, to some larger scale thoughts about where particular fault-lines can be seen / heard in electronic music, as a particular, historically located set of practices. The schema proposed by Steven Feld (1984) for interrogating a musical culture in terms of questions regarding the roles of competence, form, performance, environment, theory and value / equality, although directed at a more general scale of inquiry, nonetheless provides a helpful scaffolding for outlining these

concerns, and for providing a rough mapping on to the remaining chapters of this dissertation.

Competence can be presented in a number of ways in live electronic music. At performance time we can see how various kinds of competence can be evident, or absent, in relation to the categories of Bowers; for instance, through technological means, social competence displayed by attentive listening to co-players, or cultural competences through the deployment of particular materials. Nonetheless, it presents itself as an ongoing problematic in electronic music in that the degree of gestural dislocation can make it hard to discern the exercise of skill, particularly those sorts of skill conspicuously associated with musical performance (see, for instance d'Escriván, 2006). Furthermore, technologies and technological paradigms carry with them their own symbolic capital which can be used to signify particular kinds of cultural or technical competence (Prior, 2008); mixing of technological paradigms can, in turn, be used a means for treating this connotation as a dimension for play (Bowers and Archer, 2005). Electronic music makes plain the intertwining of equipment and skill, and the extent to which these are rendered scrutable in particular ways in particular interpretative settings; Waters (2007) suggests that this reveals a fuzzy distinction in practice between performer-instrument-environment, which I use as a starting point for theorising a particular perspective on technology and skill in the following chapter.

Form As is perhaps evident, I am following Bowers in treating matters of social and material contingency as being significant to the form of live electronic music; Bowers himself notes that, within the rubric of *abstract* and *abstracted* forms offered by Emmerson (1986), improvised electronics would appear to have most obvious affinity for *abstracted* forms that emerge through the co-mingling of various contingencies, but that equally more *abstract* types of form are readily available through the deployment of algorithmic control (Bowers, 2003). Nick Collins (2009) likewise notes that "moment form [see Kramer (1978)] ... with its concentration on the immediate scene free from outside connection, is a natural setting" for certain types of electronic music. We might add to this a note that it can be the liminal points of such moment-focused performances that are least satisfying (rather than a problem with moment

form *per se*) as poorly performed transitions can fail to maintain tension, or the same types of transition can become tedious. Marco Stroppa (1999) observes that for 'mixed' configurations where the electronics are dependent on material from the instruments certain types of forming become almost inevitable if the electronics are always heard as a lagging counter-voice.

As with the examples discussed in Section 1.1 (p. 32), my main interest in this research has been in forms that are emergent, depending on the ways that musical activity has been arranged. To the extent that computer mediated ways of embodying these ideas exercise some degree of indeterminate musical agency (like Di Scipio's *Audible Ecosystemic Interface* and *Voyager* by George Lewis), then there are three broad forming forces at work: formal ideas as embedded in the algorithm or associated technology (e.g. somewhat explicit guidance on formal expectations in Di Scipio's *Background Noise Study*); formal workings-out in play by human actors[12]; and the potential for active algorithms to, in cricketing terms, bowl a googly by doing something wholly odd. Whilst it might be tempting to theorise this as arising in the fold between what is composed and what is performed, the potential for these interjections to exhibit unimagined / non-designed behaviour warrants considering this as a forming locus unto itself; on this basis, for instance, we can point to a distinction between *Background Noise Study*, which hinges on a well-tuned, and quite tightly steered coupling between algorithm and environment, and *Voyager*, where Lewis is more interested in a system that serves as a co-player with its own distinct behaviours (Lewis, 1999).

Performance and Environment In keeping with the personal and idiosyncratic nature of much work in live electronics, most especially in the development of instruments and interfaces, but perhaps at odds with the idea of compositions as musical units taken to be fungible between players, the focus of this research has been on work in which I perform, sometimes with specific other people. This is in part a byproduct of the fact that one focus of the research has been on stepping out of the studio and developing a personal (co-)practice in live electronics

[12] I am crediting people, however unfashionably, with having an altogether different order of contextual awareness, memory, projection and sense of humour than active machines, no matter how 'intelligent' (Dreyfus, 1992)

and, as such, the pieces are reflective of particular moments of personal development (or, rather, accretions of successive, particular moments) and of particular musical relationships within my local community of practice. Nevertheless, they are also shaped by the expectation, and thus the normative conventions, of public performance; recognising that there may well be music that is more interesting to play than to witness (and vice versa) reveals another potentially fertile territory to be worked through. Likewise, differing (technical, social, aesthetic) affordances and expectations of different performance sites and their attendant interpretative games present intriguing challenges; is there a trade-off between access to particular levels of technical sophistication and types / degrees of conviviality? As a practical and aesthetic matter, what aspects of an electronic musical practice can be nomadic between diverse sites / games?

Such questions emphasise the degree to which performance is environmentally situated, and the extent to which we may make assumptions about performance environments in advance; recall from Section 1.1.1 (p. 32) the problems encountered performing Di Scipio's quite delicate piece when the 'signal to noise' ratio was perhaps not as anticipated. For pieces, like *Background Noise Study* and all those in the accompanying portfolio, that employ 'machine listening' in some form this raises some interesting practical issues that can be approached as another terrain for exploration; namely, how to cope, musically, with sometimes highly disparate degrees of clarity and control such that they can be *played* with (or against).

Theory, Value and Equality These broad categories of Feld's obviously need some reining-in to be rendered manageable for what is a survey of a slice of practice, rather than of a whole musical culture. We can do so readily on two fronts. First, as an echo of the comments above around competence, we can usefully remain alert to the ways in which musicking with computers, especially, involves the performance of a particular kind of technological knowingness (Prior, 2008). These types of knowing, and who is presumed to be able to do them are political matters, bound up with struggles over race, gender and class.

For instance, deliberately flouting conventions of technical practice can provide a productive space in which to play with associations of techno-

logy and competence, but being in a position to do so can be a marker of privilege insofar as interpretations of such tactics are liable to be inflected by culturally dominant prejudices about who is 'good' at technology (Rodgers, 2004). Such dominant assumptions are contributed to by our historical narratives, so we should be alert to reinforcing lacunae in those histories, such as the neglect of early live electronic practices by AACM musicians reported by Lewis (2008), or of the involvement of women in early electronic music discussed by Tara Rodgers (2010).

Second, is the consideration of how live electronics as a research enterprise and a set of musical practices—and this work as a specific endeavour—relates to such questions of value and equality. We can suggest two broad axes here: musical and documentary. Musically, how, in practice, might we best heed Landy's call to offer things to 'hold on to' (Landy, 1994)? Further, what ways are there of pursuing wholehearted hybridity and cross-pollination between styles, sites and interpretative games that don't slip into lazy exoticism? On the documentary front, to whom and how are the documents of practice useful? Are there ways of disseminating these that truly contribute to greater access to the practice, or that could even help lay the foundations for convivial co-practices in the future?

1.5 Summary

Taking a view of composing for improvising in terms of a negotiation about the division of musical activity, we have seen, through some first-person accounts, how some issues local to my live electronic improvised practices manifest in practice, and how (following John Bowers) these can be viewed as contingencies in social, technical and musical terms. These I have formed into the broad territories above that serve as motivating interests for the practical aspects of this research, and in turn help provide a mapping for the remainder of this thesis.

The following chapter presents a theoretical contribution that considers in further depth the performer-instrument-environment relationship (Waters, 2007) with a focus on key issues encountered in the above discussions of *competence* and *theory, value and equality.* I take an epistemological position that follows both recent theories of embodied and enactive knowledge (Clark,

1997; Varela, Thompson and Rosch, 1991) and critical philosophy of technology (Feenberg, 1999) and develop a perspective on musical skill that seeks to sidestep an uncritical prioritisation of virtuosity and novelty. By presenting a non-essentialist argument, I seek correspondingly to develop a perspective that avoids promoting an exceptionalism of electronic musicking that I take to be detrimental to possibilities for conviviality.

The remaining chapters, 3–5, then examine the accompanying portfolio in detail, using the arguments of Chapters 1 and 2 as a foundation. They are organised around a division of the lived temporalities associated with the formation of the portfolio pieces into their current (contingent?) states. Chapter 3, *Grabbing*, traces the threads of what Jonathan Impett has called the 'originating impulse' (Impett, 2011) for each piece through the various flows of technical possibility and social negotiation by focusing on ideas of non-stationarity, dynamic stability and negotiated forming. Chapter 4, *Holding On*, moves into the temporal frame of performance, and concerns itself with the ways in which early performance experiences continued to shape the pieces, and on how the types of sites and codes of performance are of significance; this is done through lenses of bodily involvement, safety and exposure, presence, and spatiality.

Finally, Chapter 5, *Letting Go*, provides a space for methodological reflexivity and for confronting the second of the issues of *theory, value and equality* above. It does this by considering the pieces as artefacts and examining the affordances of the documentary approach taken for different types of academic research endeavour, that is, in terms of contribution to different types of institutional knowledge. Furthermore, I ask whether and how the approach taken would need to be different to support a broader contribution to electronic musicking that privileges the types of conviviality, hybridity and portability I develop as aesthetic priorities throughout the thesis; this helps define space for a continuation of this line of research which would look at this question in detail from a practical perspective.

Chapter 2

Skill, Agility, Playfulness

2.1 Introduction

> Musicking human beings have always explained and understood the relationship between body, instrument and environment as dynamic and mutable. Our digital present is no different. It is not fundamentally distinguished from other eras by the problems and opportunities presented by its ubiquitous technologies ... (Waters, 2007, 14)

The idea of a performance ecology or ecosystem has been used by Bowers (2003) and Waters (2007) to develop a perspective on the materialities of contemporary digitally mediated musical practices which recognises that material resources such as instruments and technologies inhabit a world rich in social, material and historical interconnections that inform practice. In this respect, the idea resonates with a number of other recent contributions.

In the quotation by Waters above, as well as an apparent affinity with the work of Christopher Small through deployment of the term *musicking* (Small, 1998, see also p. 20), there is also evident a concern for reintegrating the theorisation of artefacts and human practices into an account that recognises the evident interconnectedness of lived experience.

Besides musical research, such reintegrating has become a concern in other fields. Of particular relevance to the practices around contemporary music-making are different strands of work in the biological and cognitive sciences that emphasise the co-dependencies between minds, bodies and environments in human life (Varela, Thompson and Rosch, 1991; Clark, 2008); work in the social sciences that examines the relationships between computer-based activity in terms of its situatedness (Suchman, 2007); attempts in anthropological discourse to bridge the gap between the cultural and the biological (Ingold,

2000); as well as recent developments in phenomenology (Dreyfus and Dreyfus, 1986; Dreyfus, 1992) and philosophy of technology (Feenberg, 1999, 2002). These have started to have some influence in discourses around contemporary music-making, informing orientations towards composition (Di Scipio, 1998), instrument design (Armstrong, 2006; Essl and O'Modhrain, 2006), listening practices (DeNora, 2000; Clarke, 2005; Windsor, 2000), and electronic musical culture (Emmerson, 2007).

I also read the querying of the stability of performer-instrument-environment divisions by Waters as being isomorphic with the analytical stance of Lucy Suchman already encountered on p. 25: 'how far our analysis extends in its historical specificity and reach, or in following out lines of connection from a particular object or site to others, is invariably a practical matter'(Suchman, 2007, 284). Waters (2007) offers examples both of contemporary digitally-mediated encounters and of engagements with more venerable musical interfaces that demonstrate how unstable these boundaries are in practice. In doing so, Waters also proposes a degree of continuity between digital and other kinds of musical practice which may seem controversial in the context of a wider contemporary culture that habitually points to the exceptional nature of digital technologies and proposes conceptual boundaries in terms of technological paradigms—acoustic vs. analogue vs. digital. These boundaries are, I think, unhelpful insofar as they may serve to obscure and foreclose opportunities for hybridity (Waters, 2000), conviviality (Emmerson, 2001) and self-reflexivity.

Conversely, in arguing for a sense of continuity between acoustic and digital musicking there is a danger of over-doing it and appearing to delegitimise, erase or brush aside people's experience of differences between one and the other. Such experiences of difference, whether positive or negative, warrant being taken seriously; different insights are yielded from locating the source of different experiences as either an essential property of a particular type of technology, or as something that arises in the ecosystem of lived relationships, as I will attempt to demonstrate.

I will seek to add theoretical support to the claim for the historical continuity of human musicking made by Waters, without erasing or delegitimising the possibilities of difference in practice. Instead, I develop the grounds for an explanation of how these arise in social and historical context. What emerges from this is a distinctly contingent notion of what constitutes the musical instrument so that acoustic and digital systems may afford more ready com-

parison (Waters, 2007). As the basis of my argument is epistemological—in that I do not see the basis of skill formation or of embodied knowledge as being significantly altered by digital means—I develop the central portion of this chapter as an extension and response to Thor Magnusson's epistemologically-orientated account of embodied acoustic and digital instrumental relations (Magnusson, 2009), by following certain 'lines of connection' out into the world and, in doing so, proposing a greater sense of continuity. In particular, I argue that such things as skills and affordances are intertwined with the social as well as the technical bases of practice, and suggest that there is value in further discussion that examines the ways in which our practices and relationships with musical technologies are inflected by the various differing sites and rituals over which they are spread. On that basis, I suggest two headings—agility and playfulness—as possible areas for developing discussion on these points and offer some elaboration.

2.2 Differentiating the Acoustic and Digital

A recent article from Magnusson (2009) has offered an argument for differentiating acoustic and digital instruments in epistemological terms. His theory makes two particular contributions that I take as being especially valuable to an ecosystemic perspective on music and performance. The first is to provide, via the theories of mind and cognition of Varela, Thompson and Rosch (1991) and Clark (1997), an account of the growth of musical skill that recognises the importance of tacit knowledge[1] as a feature of embodied personal growth that emerges through exploring and forming the world of material and social relationships we inhabit. Secondly, he accords an active role to equipment by noting that devices can exert agency and serve as scripts for action. For Magnusson, the former is paradigmatic of acoustic instruments, whilst the latter is argued to be inherent to digital instruments. Thus, an *essential* difference is proposed whereby 'software has agency and necessarily inheres more cultural specifications than any acoustic instrument' (Magnusson, 2009, 175), such that our interactions become less embodied and there is greater potential for the foreclosure of creativity or the imposition of restrictive cultural horizons.

Insisting on the *necessity* of this difference is problematic, insofar as it would seem to take on a somewhat deterministic quality unable to account for

[1] Tacit knowledge can be succinctly expressed as a concept as 'knowing how' rather than 'knowing that' (Dreyfus and Dreyfus, 1986, 3; see also Polanyi, 1966).

the complex range of creative relationships people have with musical equipment. However, there is scope to expand upon Magnusson's argument such that we can retain his important foundational observations whilst providing an alternative explanation for experienced differences between instrumental types that avoids a deterministic implication. To do this requires a slight zoom outwards in viewpoint, placing the analytical cut at a different point in the network. As is not uncommon, Magnusson's discussion revolves around the nature of relationships to *the* instrument. In doing so there is a tendency for the focus of comparison between acoustic and digital music making to collapse down into the material boundaries of whatever particular device is taken to be the locus of sound production, so that we might compare a piano and a laptop. However, such a perspective obscures a range of important features that can serve to mitigate the degree of difference between technological paradigms. By taking an analytical step back, we can place these apparently context-free objects back into the type of world in which they are encountered: a world in which these objects form a part of a network of relationships with other objects and with people.

Magnusson (2009) makes four particular claims that he sees as underlying difference between acoustic and digital paradigms. Firstly, that while the design of acoustic instruments is characterised by a bottom-up, empirically driven and embodied engagement with materials, the design of digital instruments is a top-down matter that involves the application of rational conceptual principles. Secondly, that this difference of design orientation follows through to a difference of usage orientation; whilst engagement with acoustic instruments is embodied, the degree of symbolic mediation inherent to digital tools breaks this embodiment. Thirdly, this difference of engagement means that whilst the process of skill formation with acoustic technologies is related to the gathering of tacit knowledge through situated experience, with digital instruments enskilment is necessarily orientated to a process of symbolic understanding. Finally, that because this enforced process of understanding is taken to be almost wholly on the terms of the digital instrument's designed affordances, digital tools thus possess an active character absent from acoustic instruments.

Each of these apparent sites of difference largely evaporates when our isolated instruments are placed back into a fuller social and material world, such that we can take our interaction with digital instruments to rest on the same

basis of embodiment and networks of tacit knowledge, and recognise the active nature of acoustic technologies.

2.2.1 Bottom-Up Empiricism and Top-Down Rationality

The idea that the design and manufacture of acoustic instruments can be characterised as being craft-orientated, led by 'bottom-up exploration', whereas digital instrument design is necessarily tied to the top-down application of rational theoretical principles is on the face of it a persuasive generalisation (Magnusson, 2009, 173–4). Nonetheless, it is a generalisation, as Magnusson (2009, 173) acknowledges. The basis for explaining differences between technological paradigms shifts significantly if we cease to treat these design orientations as mutually exclusive. There are two components to this. The first is to consider the question in terms of the specific *type* of rationality that Magnusson implies when he talks of 'a mathematical understanding of sound' (p. 174), insofar as this represents a particular corpus of conceptual scaffolds. The second is to consider the nature of the conceptual apparatuses in making more generally.

On the first front, scientific knowledge can be seen to have been applied to the design of acoustic instruments alongside more exploratory design strategies. This is particularly evident with various innovations in the design of woodwind instruments during the 19th century (Campbell, Greated and Myers, 2004). Conversely, we can observe that not all approaches to digital instrument design are predicated on the application of scientific knowledge, such as with George Lewis's account of developing *Voyager*:

> Avoiding scientism on the one hand and anthropomorphism on the other, I don't feel the need to 'scientifically' prove the validity of any process I use to get my music to sound the way I want it to sound. I feel utterly free to work in an intuitive way while programming computers to create improvisations. This necessary combination of the utterly logical and the completely intuitive is what attracts me to this kind of work (Lewis, 1999, 110).

Secondly, the relationship between making and the world of ideas appears a little more complex. Magnusson notes that in order to design digital musical instruments, extra-technical ideas about music itself are filtered through the top-down, symbolic process of modelling:

> Writing digital musical interfaces therefore necessarily entails the encapsulation of a specific musical outlook ... the designer of the composed digital instrument frames affordances through symbolic design, thereby

> creating a snapshot of musical theory, freezing musical culture in time (Magnusson, 2009, 173)

The need to model, Magnusson argues, is inevitably reductive because such numerical models are partial; complex and dynamic ideas like 'music' are irreducible to a finite set of symbolic parameters. However, the interaction between tool design and conceptual ideas becomes more complicated when we consider that this process of reduction is not the only way in which designs and extra-technical ideas interact. Andrew Feenberg notes that reductions are accompanied or compensated for by further interventions from both designers and users in a process he calls 'mediation' (Feenberg, 1999, 206). These interventions are unconnected to the technical logic of the device but have to do with its suitability for particular social contexts, such as decisions about 'look and feel' or the range of functionality that is exposed. The concept of mediation applies equally to the ways in which our equipment is packaged and marketed and subsequent ways in which users may customise or modify equipment, ranging from the cosmetic, such as taping over the Apple logo, to the more drastic and invasive, such as circumventing copy protection.

Feenberg argues that these mediations establish feedback loops with the processes of reduction in design, as certain interventions are liable to become enshrined over time as design principles, either explicitly through legislation and standardisation, or implicitly through convention. Thus, the top-down design process takes on a less linear and more interconnected character as something embroiled in a complex set of historically and socially situated interactions, not only with ideas about the *thing being modelled* but also with ideas about the *modelling of the thing*. Furthermore, this process takes on a continuous and dynamic quality when interventions by users are considered. Designs are only ever contingently complete as they are always subject to modification in order to adjust their fit to sets of ideas outside of their technical logic.

2.2.2 The Boundaries of the Instrument

Mediating interventions on technologies also spill out into the world, over the boundaries of any particular device. Consider, for instance, the report by John Bowers that

> organisation of my playing environment make things more effective for me, it gives clues to the legibility of my gestures, both for co-performers and audience ... by moving from one side of the table to the other I can

> do different things and be seen [and heard] to be doing different things (Bowers, 2003, 47).

Bowers' design is not simply a matter of modelling musical preferences and devising more or less optimal ergonomics, but is also inflected by preferences about his social relationships in performance, which in turn affect the way in which resources are interconnected and located in space. As the use of physical space becomes part of the design, the conceptual boundary between instrument and environment is rendered more ambiguous.

This ambiguity has explanatory potential when considered in relation to two ideas from Feenberg and from Clark. Firstly, that just as the technological objects we encounter are very often *systems* of other technologies that have been interconnected and coupled, so usage also very often consists of assembling systems of interconnections and couplings. Feenberg argues for a degree of equivalence between these two forms of what he calls 'systemisation' (Feenberg, 1999, 205). This is particularly evident in computers, which are highly complex coalitions of interconnected and interdependent systems, but is also familiar to any user of audio technologies where much activity, both physical and virtual, consists of making assemblages of interconnected components. Secondly, systemising activity is more radically positioned by Clark as being integral to ways in which our cognitive processes can be seen to take place in continuous interaction between our brains and bodies and the wider environment. Clark argues that cognition involves continuous acts of 'ecological assembly' (Clark, 2008, 13), where external resources are enrolled into ad-hoc networks in ways that distribute the cognitive burden of some task out into the world. Significantly, how technological or even how material a resource is does not appear to have much bearing on how likely it is to be involved in such a network, as Clark identifies a cognitive tendency to use whatever is at hand, resulting in complex mixtures of material resources, uses of space and organisation, and the deployment of symbols as ways of thinking through the world.

So, just as we can regard a computer as a system, it is also part of a larger ecosystem of potential interconnections some of which may be physical, some of which may be mediated by the virtual activities of our brains. Furthermore, if Clark's account is true, then there is a case for regarding the systems we make and encounter around acoustic instruments as contingent unities in their own right, so that under some conditions, systems such as instrument-score (and more complex extensions) can be considered as constituting the bound-

aries of the instrument. Thus the instrument becomes a term for describing the coalition of resources being used *at a particular moment*, as Franziska Schroeder and Pedro Rebelo observe:

> Instruments are never stationary but are always given within a constantly changing, indeterminate background or horizon. Consequently, they are context dependent and, furthermore, the context itself is temporary and always subject to change (Schroeder and Rebelo, 2009, 136).

Redrawing the boundaries of the instrument in this way means that the presence of symbolic mediations in our musical systems can be seen not to be an exclusive property of the digital, but are conspicuous throughout our environments and acts of assembly. With this in mind, we can examine the idea that symbolic forms can disrupt embodied relationships with the world.

2.2.3 Embodiment, Symbols and Computers

Magnusson suggests that 'to work with symbolic tools means that one has to continually switch modes from focusing on the world to focusing on the tool with regular intervals and to a more pronounced degree than in acoustic instruments' (Magnusson, 2009, 173). This continuous switching implies, for Magnusson, an interruption of our *embodied* inhabitation of the world that yields to a *hermeneutic* orientation, based on intellectual understanding. Consequently, he argues that tacit knowledge, which is the basis of skilled action that applies to acoustic instruments, gives way to skill development through intellectual understanding for digital instruments. I will examine this in two parts, as it is a complex claim. In this section I will argue that with digital systems our interactions remain embodied. I then consider the implications of 'understanding' and skill formation in the following section.

If we follow Magnusson in accepting the role that tacit knowledge, gained through active exploration in the world, plays in skill formation more generally, and accept my claim that as a result of ecological assembly symbolic mediations in music are not exclusive to digital systems, then it remains to be considered whether there is something peculiar about the nature of computers, or about the specific types of symbolic mediation employed that disturbs embodied engagement. Armstrong (2006) contributes a useful discussion on this point that identifies the switching of modes, described by Magnusson above, as being a continual feature of human cognition rather than an extraordinary

symptom of computer usage [2]. In this sense, then, the switching of modes by itself does not appear to account sufficiently for a detachment of our engagement. What Magnusson describes when he distinguishes between focus on the world and focus on the tool is encapsulated in Heidegger's concept of the 'breakdown' that occurs when performative flow is disrupted and the Otherness of the instrument becomes suddenly apparent (Armstrong, 2006, 64). Such an experience is obviously not limited to digital instruments, but are there grounds for treating breakdown as an inherent property of the digital?

Initially, we can perhaps place different computer orientated musical activities along a nominal continuum of embodiedness. We could, for example, consider performing EQ adjustments in real-time; selecting and refining parameters for offline processing; and non-live (undead?) coding as being progressively more distant from direct, bodily engagement with the world. EQ adjustment is uncontroversially embodied: the character of my adjustments is continually guided by what I hear. In the case of the more temporally interrupted process of applying, auditioning, refining and re-applying parameters, there would seem to be a case for this being characterised by more textual-engagement. However, assessing what the various symbolic options on offer *mean* in context still happens out in the world, beyond the boundaries of the symbolic system. The possible interactions between the parameters of, say, a phase vocoder, and any particular sonic material are sufficiently complex that it is simply not possible to determine in advance *without a lot of practice* quite what the result might be.

Even when writing code, which would seem on the surface to be paradigmatically disembodied, it is possible to flow such that the separateness between the machine and me seems to dissipate. When coding most fluently, I find that rather than simply implementing some structure that I have imagined in my head, what happens is *between* myself, the computer and the environment. I will play with space in the code as a way of helping me think more clearly about a particular bit; I will make use of doodles, post-its, changes of posture and musing out loud, as my work overspills the boundaries of the coding environment.

These very simple examples suggest that, as embodiment can happen with digital interfaces, the reasons why breakdown occurs are reducible neither to

[2] Armstrong's argument makes use of the concept of 'double embodiment' described in Varela, Thompson and Rosch (1991). This notion captures two complementary senses of embodiment: the body as our physical housing, and the body as the site of lived experience in the world (xv).

the presence of symbolic mediations in the instrument, nor to an inherent property of digital interfaces. It is in more complex settings such as performance, however, that disruptions of flow are commonly experienced. Performing brings to bear networks of interrelated skills, many of which depend on being able to maintain focus on the world at large. Yet it is not reducible simply to an aggregation of skills, because the qualitative aspects of what we try to achieve when performing are inflected by social and cultural aspects of the environments in which we perform. The *meaning* of the symbolic aspects of an interface are in turn inflected by the wider context at hand. I argue in the following section that by situating our understanding of symbols in context they are subject to continual and contingent reevaluation, and that the propensity for breakdown lies at the intersection of socially informed intentions and the technical affordances of the instrument.

2.2.4 Do You Read Me? Understanding

> how do computers, as necessarily symbolic devices, enable, produce, maintain, support augment, but also constrain and limit our cognitive processes and therefore creative output? (Magnusson, 2009, 169)

Discussions around the significance of particular symbolic forms—scores and texts—are well-established musicological concerns. Significantly, for the purposes of this discussion, the nature of such texts as authoritative, autonomous, *self-contained* carriers of meaning has been called into question in the musicology of recent decades (Cook and Everist, 1999), just as such notions have been rendered problematic for texts and symbolic forms more generally by currents like post-structuralism. Is there a reason to suppose that the symbolic forms that we encounter when we use digital tools are particularly different in this respect? I propose that there is not, and that this is made clearer when we adopt an analytic perspective that situates player and instrument into a rich social context. Two points arise from this. First, it becomes possible to view the process of enskilment with digital systems as involving the same degree of tacit knowledge and situated understanding as Magnusson rightly identifies with acoustic systems (Magnusson, 2009, 170). Secondly, we can reposition the affordances of systems (or their lack) as arising in the particularities of the social, material and historical context at hand. This helps move towards answering Magnusson's question at the start of this section in a way that sees such a dual aspect of computers as a property of any technology *in situ*, rather than of digital tools in particular. One persuasive reason for re-

garding the symbolic forms used in digital interfaces as different and possibly less ambiguous than other texts is that they refer to technical and quantitive concepts that are simply *there to be understood* so that 'ergonomically, the interaction happens primarily through a symbolic channel, which gradually teaches the user to operate with technical terms (such as "low-pass")' (Magnusson, 2009, 174). The meaning of a concept like 'low-pass' is, of course, easy to describe *in the abstract* as a filtering operation on a signal that admits energy below a certain frequency threshold whilst rejecting energy above it. However, such a definition does not encompass the range of possible things that a person might understand the term to mean in practice. We can perhaps map this ambiguity on two broad fronts.

The first is that people bring with them historically contingent interpretations of concepts like 'low-pass' that are shaded by lived experiences. That is, one's understanding of what a filtering operation is will be shaped by previous encounters with this and related concepts. We may understand filtering operations more or less solely in terms of our sonic experience of them, as memories and projections of their interactions with different types of sonic material, or we may understand them in more technical, conceptual terms as specific types of circuit or difference equation. These are evidently schematic depictions, but sufficient to make the point that the epistemology of a concept like 'low-pass' is at least partially accounted for by histories of people's prior encounters.

Secondly, it follows that what we understand by such concepts as individuals changes with time and context. Most practitioners will understand the concept of 'low-pass' from multiple perspectives, both sonic and technical, and this understanding is subject to constant revision. Moreover, particular understandings are informed by context; what we are doing, and who we are doing it with. Consider, for instance, the range of particular meanings that the numeric properties of an equaliser may have. For somebody new to such things, there is little or no experiential basis for associating these numbers—frequency, gain, resonance—with any particular aspect of what they are hearing. The numbers demand attention as they learn, for example, how frequency as an aural phenomenon maps to frequency as a numeric range, helped or hindered to some extent by the clarity of their listening situation.

Such learning is necessarily an active, empirical affair. When we search around with an equaliser trying to locate some specific aspect of a sound, this can be likened to what Tim Ingold has called 'wayfinding', as distinct from

what he calls 'navigation'. The latter, Ingold argues, is characterised by knowing in advance one's destination, the former by knowing one's destination when one gets there (Ingold, 2000, 235–7). This description of wayfinding characterises working with sound well, and applies particularly to skilled, expert use; one *knows* when the right point has been arrived at without necessarily being able to articulate how one knows. Skilled practitioners will home in more quickly as they have learned to interpret the response in the sound as a guide of where to go next, developing skills that are akin to Sudnow's characterisation of 'grabbing' for the right chords on the piano (Sudnow, 1978).

The distinction between wayfinding and navigation yields two additional, related points concerning the development of skill and the possibility of breakdown (see previous section). Ingold proposes a further distinction between mapping as an activity, and maps as artefacts. The former, he argues, can be considered as a 'narrative re-enactment' of our wayfinding (Ingold, 2000, 234), that is, as a learning process that arises through doing. The latter, on the other hand, is a guide to navigation: a set of instructions for getting from A to B.

Concerning enskilment, we can see that numerical parameters might initially serve as a map for novices, who are given to seeking out advice in the form of particular parameter recipes to accomplish a particular task [3]; experts, on the other hand, will be able to proceed intuitively, finding their way through the interaction of material and processor on the basis of learned, tacit skills (Dreyfus and Dreyfus, 1986). The parameters come to mean something quite different in each case. For novices, the numbers define the territory; the audible spectrum, for instance, becomes divided into pre-established zones where particular instrumental characteristics are taken to live (vocal presence at 5 kHz, for example). For experts, the relationship is reversed, as they have learned the skill of translating back from what is heard to a numeric representation.

On the second point of breakdown, Ingold's distinction resonates with mapping in the sense of determining which external controls affect what parts of a digital algorithm. In particular, we can interpret critiques of unsatisfactory experiences of overly simple and direct mapping strategies in terms of the degree to which such schemes afford only navigation rather than wayfinding, thus militating against skilled development whilst also giving rise to break-

[3] These sorts of questions can be readily observed both in the advice columns of magazines like *Sound On Sound* and on internet forums like gearslutz.com.

down more frequently. By this measure, these problems are not intrinsic to the digital nature of our interfaces, but are related to particular choices by interface designers about what they expect their interfaces to mean to users. Direct parameter mappings of a granulator, for instance, are not especially musically suggestive, but are probably also quite opaque to someone unfamiliar with granulators. Fortunately, however, more wayfinding-orientated approaches to mapping are available (Bowers, 2003; Van Nort and Wanderley, 2006).

Finally, our interpretation of symbolic channels is also inflected by context. Nominally technical concepts and their symbolic representations are enlarged by connotations specific to social and material circumstances. The meaning of numerical parameters is tied up with the complex interaction between a process and the signal it operates upon. For instance, what counts as a 'large' resonance setting for a filter depends on the sonic material, the particularities of the filter being used, the job at hand (techno filter sweep or mastering?) and the propensity of the loudspeaker-room-listener system to pick up on those changes. Moreover, in discourse quite what these concepts are taken to mean is sensitive to what is being talked about, and the relationship between interlocutors, as indicated by Thomas Porcello's investigation of the different uses of technical and metaphorical language between experts and novices in recording studios (Porcello, 2004).

The process of developing expertise with digital systems is not merely a case of coming to an understanding of a technical system *qua* technical system but of developing complexes of skills that loop through and around the instrument (some of which will take the form of tacit knowledge), because the use of symbolically mediated systems still hinges on bodies of tacit knowledge extrinsic to the device itself. This, as Clark points out, applies equally to symbolically mediated activities on computers (like playing Tetris) and to playing piano (Clark, 2008, 75). Skills arise within 'the whole system of relations constituted by the presence of the artisan in his or her environment' (Ingold, 2000, 291; Suchman, 2007, 262), a system of relations that includes interaction with other agencies and with various traces of histories and cultures. Furthermore, the meanings of technical concepts encountered in technology arise, irrespective of their digitality, in this same system of relationships, as Feenberg says: 'the social character of technology lies not in the logic of its inner workings, but in the relation of that logic to a social context' (Feenberg, 2002, 79).

2.2.5 Active Technologies

This brings us, finally, to the idea that digital instruments manifest some kind of active quality or agency where other technological paradigms do not, an argument made by both Magnusson (2009) and Bown, Eldridge and McCormack (2009). Within the context of contemporary performance practices this is clearly a notion that needs accounting for as various artists' work involves systems that exhibit some degree of autonomy of operation, such as George Lewis's *Voyager* (Lewis, 2000), Arne Eigenfeldt's agent-based systems (Eigenfeldt, 2008), and Agostino Di Scipio's *Audible Ecosystemic Interface* (Di Scipio, 2003). However, for all that our digital instruments, as highly complex systemisations of technologies (see Secion 2.2.2, p. 72) may make this active nature more apparent, there are grounds for not regarding it solely as an attribute of digital technologies.

Considering first the condensed ecosystem of player-instrument, or agent-tool, relations, Ingold helps us appreciate that the material resources of un-digital practice are not altogether passive with a detailed account of wood-cutting in which the character of action can be seen to be in response to the very particularities of the wood and the consequences of prior acting (Ingold, 2006). Perception and action, as Magnusson describes, 'co-emerge through the agent's active involvement with the world' (Magnusson, 2009, 169), rather than the process of making being one of mechanically executing an intention preformed in all its particulars (Ingold, 2000, 294–311). This resonates with Simon Waters' and Bennet Hogg's depiction of 'the violin as lie detector' (Waters, 2007, 5), highlighting that the instrument is far from being passive, but is a participant in an on-going negotiation.

We might, however, regard digital technologies as being especially active because, as Magnusson notes, they seem to embody knowledge in such an explicit manner. Computers are, by this account, tools for automation, things to which we delegate tasks in formalised terms. Consequentially, they exhibit agency by apparently making skilled human action peripheral where once it was central; hence the concern expressed by Vaughan that the transition from analogue tape orientated studios to digital workstation orientated studios could herald a process of deskilling (Vaughan, 1994). However, Ingold provides an additional insight when he notes that 'as fast as machines have been contrived to do what had previously been done by skilled hands, different skills have sprung up to cope with the machines themselves' (Ingold, 2000, 332). Again, this can be seen to apply equally to digital and non-digital

technologies. Just as delegating the role of co-player to a computer, as Lewis does with *Voyager* will entail human players developing skills to cope with the computer-player, so the delegation of remembering certain features of a musical work to scores or recordings (Frith, 1996, 226–7) opened up new realms of skilled action.

Finally, we may question whether the propensity of digital systems to 'script' action really is a special property of a given device or class of device when we consider the instrument as an assemblage of material and immaterial resources rather than as a single artefact. 'Agencies—and associated accountabilities—reside neither in us nor in our artefacts but in our intra-actions', writes Lucy Suchman (2007, 285), so that when technologies seem to script our action, this scripting is as much a social matter as a technical one. The apparent imperatives of given technologies exist as matters of convention and consent in the same way that cultural codes of behaviour, dress, language and music arise through the co-dwelling of humans in environments shaped and filled by artefacts. It follows that to withdraw consent, to disrupt apparent imperatives is also a socially inflected matter rather than a purely individual action.

When it seems that our digital systems are imposing upon us restrictive 'cultural specifications' (Magnusson, 2009, 175) then this can be understood more fully as arising in a particular complex of social, historical and material circumstances than as an inherent property of digitality. It allows us to acknowledge, for instance, that those things we are trying to achieve that the computer appears to be 'making' difficult are socially constituted aims, whether that be virtuosity (Jordà, 2004), intimacy (Cook, 2004; Plans Casal, 2008), or togetherness (Schroeder et al., 2007). Cultural specifications and, it follows, affordances arise in the fold between our socially and historically ensconced priorities and the social-technical histories of our machines, themselves reflective of particular priorities. Affordances, therefore, are partly constituted by convention and by consent. Consent can be withdrawn, of course, and new affordances are found by disrupting what is taken to be correct usage or by trying to achieve something apparently perverse—such as when Phil Archer deliberately overloads his CPU to create variations of current on a USB bus that is controlling a slide guitar made from eviscerated CD players (Archer, 2006, 24–5). This noncompliance is socially inflected in the same manner; apparent perversity is relative to socially situated expectation, and

affordances for disruption emerge more readily in a social milieu that sanctions such things.

2.2.6 Summary

The epistemic features that seem to distinguish the digital from the acoustic when viewed from the close-up vantage point of player-instrument dissipate somewhat when we zoom out and consider players and instruments as situated in an ecosystem of connections and histories.

1. 'Top down' and 'bottom up' design practices are less readily distinguishable, as a complex web of different types of conceptual framework that relate and interact in various ways can be seen to feature both in both digital and acoustic making.

2. Artefacts are systems within systems, and can readily incorporate disparate mixtures of the high- and low-tech, and material and immaterial resources, such as symbols and ideas. The practical boundaries of instruments, under such a view, become contingent and dynamic, prompting the suggestion that such configurations as violin-plus-score may be considered as an operational unity that presents symbolic mediations, like a digital instrument.

3. Symbolic mediations are not unique to digital systems, and do not, on their own, account for breakdowns of embodied flow.

4. The symbolic components of performance ecosystems are not stable channels of fixed or unambiguous meaning, but are subject to contingent interpretation in practice. Digital instruments, like acoustic instruments, are interacted with on the basis of mixtures of tacit and formal knowledge.

5. The propensity for agency of digital instruments is also present in the acoustic realm, both through the active nature of working with raw materials and acoustic instruments and through the way that both opportunities and foreclosures of creative potential emerge in the context of particular social, material, historical and political systems.

It is worth emphasising again that arguing against the *necessity* of the difference between acoustic and digital instruments is not an attempt to negate or otherwise devalue the experiences of such difference. Rather it is an

attempt to relocate the explanation for such experiences to a wider context with, I believe, more explanatory potential, and to propose that where digital instruments might seem particularly potent in their 'cultural specification', this is a difference of degree that arises in particular configurations of people, materials, symbols and histories.

That our relationships are spread out to such an extent across the worlds we inhabit serves to remind us that our practice is similarly diffused, something in Ingold's terms in which we *dwell* (Ingold, 2000). When we come to perform and design digital instruments we bring to bear a range of cultural, social and bodily competencies beyond the technical ability to communicate with the machine on 'its' terms. Where there do seem to be significant differences in the musical experience between digital and acoustic practices then in addition to Magnusson's call for designers to take seriously their potential in establishing cultural horizons, it is also a matter for practitioners to communicate about, both between themselves and more widely. Specifically, there may be fruitful discussion to be had on the kinds of conjunctions of skills, priorities and preferences we find ourselves bringing to bear, and the kinds of coping strategies we develop.

2.3 Agility and Playfulness

By way of two possible headings to orientate such discussion I would like to suggest 'agility' and 'playfulness' as interleaving manifestations of skilled practice in music. These do not constitute part of an attempt to establish a taxonomy. Rather, I am interested more generally in finding ways of languaging (Maturana and Varela, 1992) about musicking (Small, 1998) responsive to the array of different sites, temporal orders and social conditions that practice spans.

Agility and playfulness provide two possible points of focus for reflection on how various types of, possibly tacit, knowledge about the *interaction* of different components of the performance ecosystem inflect our action and constitute aspects of our craft. Both concepts have connotations of movement. In play, argues Martin Dixon, we engage in 'a circular—more especially a non-telic—movement of free, unencumbered passing and exchange' (Dixon, 2006, 20). By contrast, there is a telic aspect to agility that describes something of the quality of movement from moment to moment.

2.3.1 Agility

Agility can perhaps encompass the varieties of moving that are involved in performance as well as the kinds of movements between performative sites, musical codes and ways of signifying that practice involves. It could focus on the *instrumental*: the ability to handle one's (quite possibly uncooperative) equipment in performance, or coping with a 'polyphony of polyphonies' (Emmerson, 2007, 114), with performing through technical failure, or with straightforward dexterity. At a different order of temporality, we can appreciate agility in the crafting of instruments and recordings, in negotiating the medium.

Agility could also refer to the micro-social aspects of music making: our ability to respond intelligibly to, or support co-players and audiences, or to allow shared forms to emerge between players without pushing or pulling. It could also feature in our abilities to negotiate wider social situations, such as the performative transitions between concert halls, clubs, community centres and classrooms that carry perhaps more dramatically different social than sonic codes. Finally, we could think of agility in terms of larger scale social levels, such as negotiating the contemporary profusion of genres and signs.

2.3.2 Playfulness

Playfulness is suggestive of ways in which we can orientate movements with respect to the context in which we find ourselves, the manner in which we conduct our 'wayfinding' (Ingold, 2000, 235–7, see Section 2.2.4, p. 77). It should not be mistaken—dominant connotations notwithstanding—for necessarily suggesting frivolity or senselessness, rather to be playful is to find a state that can admit both total commitment and total abandonment.

The idea can be usefully unpacked with respect to electronic musicking through consideration of work done by Feenberg and Sara Grimes applying Feenberg's Instrumentalisation Theory of technology to the context of digital gaming (Grimes and Feenberg, 2009), and through Richard Shusterman's theorisation of aesthetic experience in terms 'interpretative games' (Shusterman, 2002).

Feenberg and Grimes propose a critical framework through which to consider the way in which contemporary gaming mirrors the tendency of other systems in capitalist modernity towards large-scale, centralised orchestration based upon a particular form of rationality. They propose that this 'ra-

tionalised gaming' can be considered as one pole of a continuum, with free-form, self-directed playfulness at the other extreme, and a graduation of rule-boundedness and orchestration comprising the intervening territory, and term the process (from the free-form to the rationalised) 'ludification'.

Shusterman, meanwhile, puts forth the idea of an 'interpretative game' as an extension of Wittgenstein's language games to theorise the ways in which the same cultural objects or aesthetic concepts can be deployed and interpreted in quite distinct (yet consensual) ways in different historical moments or cultural contexts. So we can regard a concert, for example, as a particular, local, interpretative game in which certain historical codes of behaviour and interpretation obtain, but do not wholly determine the kinds of sense-making performed between the various networks of participants (Small, 1998); or we can consider entire genres of music to be interpretative games played out at larger, slower social scale (Born, 2010a).

Taken together, this continuum of types of play and the idea of the interpretative game afford a conceptually simple, yet rich and flexible means of deploying the idea of playfulness. We can see, for instance, that different types of play might be enacted or referred to within a single interpretative game. Concert improvisation, for instance, might be telling a story about a particular, free mode of play, in the context of an altogether more conventionally bound occasion, *within which* individuals or groups of participants (on whichever side of a proscenium arch) are liable to adopt their own more or less subversive tactics as part of proceedings.

Playfulness, like agility, can encompass different focuses. We can, for instance, consider playfulness towards tools and media in terms of a contingent withdrawal of consent to engage with them 'properly' (see Section 2.2.5, p. 81). There is an evidently playful aspect to the successive appropriations of technology that have occurred in electroacoustic music, from Cage's use of phonographs in *Imaginary Landscape No. 1* (1939) (Emmerson, 2007) to contemporary hardware hacking (Collins, 2006) and live coding (Collins, 2007a) practices.

At the micro-social level, playfulness could describe both the ways in which players orientate towards each other and the ways various mediations between players, such as scores, machines, concepts and codes, interact with and script such orientations. This aspect is perhaps most readily observed ethnographically so as to capture the specific instances in which collaborative endeavours are inflected by social and material circumstances; Sophy Smith's examina-

tion of the creative process of turntablist groups is exemplary in this respect (Smith, 2007).

2.4 Summary

The idea of the performance ecosystem invites us to consider the profusion of linkages and contingencies that make up practice and, as such, affords probing conceptual boundaries that underpin the kinds of categorical distinctions that inform discourse about musical performance, such as those between performer, instrument and environment (Waters, 2007). The idea has been used in this chapter as a basis for proposing an extension of Magnusson's epistemological account of acoustic and digital instruments (Magnusson, 2009). I have argued that by situating accounts of players and instruments into a social and interconnected world, categorical distinctions between the acoustic and the digital dissipate somewhat, and that such differences in practice are contingent upon the shifting intersections between the technical and social. This being the case, it was suggested that capturing the nature of such differences and coping with possibly negative consequences could not be achieved fully from the perspective of the designer, but needs also to refer to specific contextualised experiences of usage and performance.

Enlarging the analytical frame by the small degree that I have attempted—out from the abstracted performer-instrument and into populated, historicised environments—has involved brushing up against a number of other actors and valences further 'off-stage' (Suchman, 2007, 223). These encounters were necessarily fleeting, in the interests of coherence and conciseness; nevertheless, there are a number of immanent themes that could ground further work. Firstly, there is the issue of what sorts of methods of enquiry afford what sorts of views of the performance ecosystem, and how this may inform the various disciplinary tendencies that inform research into contemporary music. A further area for work, following from this, is elaboration on the various ways in which the technical and social aspects of music run into the political, not only in terms of the wider political economy of music (Attali, [1977] 1985), but also the role that the politics of knowledge may play in mediating access to or sanction for music making, and how this may relate to wider contemporary polities.

In the chapters that follow, some of the social context necessary for such theorising is laid out in relation to the accompanying portfolio works and the

research project as a whole. These chapters are thematised around *grabbing*, *holding on* and *letting go* and deal respectively with phenomenologies of design and practising and of performance, and with a critical positioning of this work as practice-led research.

Chapter 3

Grabbing

3.1 Introduction

This chapter documents the various 'original impulses' (Impett, 2011) that fed into the various pieces in the accompanying portfolio, and traces some of the mutations that arose in the course of trying to reconcile these impulses to contingencies such as technical ability / stability, availability, broader *techno-sonic* aims, and the often highly non-linear transition from development to practice. The subsequent chapter complements these traces by considering the further shaping effects that arose with the experience of public performance.

The aim here is to highlight certain types of linkage between the pieces and their situation in a wider practice by revealing some of the valences and forces that shaped them. Furthermore, with a forward-cast eye on Chapter 5, we are also able to bring into relief certain *disciplinary* valences at work in this research, most especially the ways in which this work has approached the domain of signal processing.

Consequently, rather than delivering a straightforward account of the technological constituents of the portfolio work, my concern here is to try to capture the slippages and findings along the way. This, I feel, is more fitting to a diachronic focus on practice and more in keeping with the orientation to technology developed in Chapter 2.

A methodological precursor can be found for what I am attempting in Sudnow (1978), where the author provides an exhaustive and idiosyncratic account of the finding of skilfulness around the piano. There are some clear differences, of course: where, for Sudnow, the technical apparatus (a piano) and eventual goal (the fluent doing of be-bop) were givens, my dealings have

been with an altogether more fluid coalition of materials and a less idiomatically rooted trajectory. Furthermore, Sudnow's primary focus was on noticing the ways of his hands, meaning that much of his action is situated in a small ecology of Sudnow-Piano, with occasional vignettes in which other actors appear. I am intent, however, on establishing a wider frame (not least as a consequence of the fluidity at work), albeit at the expense of the staggering attention to detail that Sudnow achieved.

These differences notwithstanding, Sudnow has a number of notions that are of use here. Most evocative is his usage of the word 'grabbing' (hence the title of this chapter) to describe the bodily wayfinding his hands were engaged in at the piano, particularly in the early stages of his investigation. I use it here in a similar, though less direct sense, to denote the grabbing of resources and techniques that eventually coalesced into the forms given in the portfolio.

A further useful idea comes from the way that Sudnow uses 'pathways' to describe particular routes and traversals that were given or discovered in early play; such pathways, in this case, could be either scales or particular runs that novice-Sudnow would use as his means of playing over given chords. These later seem to give way to 'courses' as a more accomplished Sudnow no longer has to rely on producing specified shapes over any given chord, but finds himself (or, as he would have it, his hands) able to proceed more intuitively based on a cultivated knowing.

These ideas, slightly stretched, have useful application here in teasing out both the physical finding of 'soundful' (Sudnow, again) ways of interacting, and the more virtual finding of ways of coaxing the computer to do as my ears might please.

3.2 Preamble: Infra-instruments, Audible Ecosystems

Two lingering presences in my work over the last few years have been John Bowers and Agostino Di Scipio. I found quite quickly that the kinds of interaction with my musicking-computer I wished for could not be satisfied solely by the processing of pre-existing sounds, controlled by some device, mediated by some mapping. There was, at the outset, a desire to circumvent the distance from the music that had characterised studio work in the period immediately preceding this research. This was not, I found, readily accomplished through using standard MIDI controllers or gaming devices. In this regard

I was drawn in particular to the idea of 'infra-instruments' put forward by Bowers and Phil Archer (2005). By using objects that are highly restricted in their sound-making capability and interactional possibilities in combination with computer-based processing, one can get a more tactile, open-ended form of interaction, and rich possibilities for combination and discovery. At the same time, I was also drawn to the Di Scipio's proclamation that 'sound is the interface' (Di Scipio, 2003), not least by the rhetorical power of his critique of the more mainstream, control-orientated approach.

These two ideas—infra-instruments and sonic-interfaces / audible-ecosystems—formed a central basis to the ideas explored in the early parts of this research, and have continued to exert considerable influence, not least for their shared exhortation to creatively re-appropriate equipment.

There is Danger in the Air, the first piece on which I started work, exhibits this in the most raw form, as it seeks to combine a Di Scipio-influenced re-circulation and transformation of sonic material with an environment of found objects through which the system is played. In a similar manner, ***And Now For Some Music*** grew around a pool of infra-instruments and a sound driven interface. In ***Cardboard Cutout***, I use a bowed cardboard box, again playing through a system driven by the incoming sound. Whilst the box had been approached originally as a candidate infra-instrument, it turned out to offer considerably more possibility for play than anticipated (see Section 3.4.1.5, p. 100, below). Finally, ***Spectral Dweller*** is a further attempt to play directly with the sonic environment.

Out of the playing I did with the ideas of infra-instruments and audible ecosystems, two particular (borrowed) notions can be used to characterise both the interactional qualities I was grabbing for, and the the kinds of timbral and durational manipulations of signals I was attempting.

3.3 Engineering and Wayfinding

A common feature of the work by Di Scipio and Bowers is that they approach the design of their systems in a way that is musically guided, rather than being orientated to the implementation of derived models of musical action. In this respect, they demonstrate the bottom-up empiricism discussed in Section 2.2.1 (p. 71), and form part of what appears to be a small heterodox tradition in live electronics.

The orthodox approach to the design of musical systems and digital musical instruments makes a set of separations—that is perfectly sensible from an engineering perspective—by considering a system in terms of a physical interface (some gesture-capturing sensors), some synthesis component, and a mapping layer between them. This, of course, affords a division of labour between the designs of interfaces, sounds and their interrelationship, but also has a number of consequences: there is the potential, as observed by Perry Cook (2004) and David Plans Casal (2008), for a distancing to result, hinging on the appropriateness and richness of the mapping between interface and sound producer, resulting in a risk that the endeavour reduces to the problematics of mapping.

There are also established orthodoxies in approaching the derivation of control information from audio signals, approached under the rubric of 'machine listening'. Computer-musicking, of course, has a long history of making use of techniques from engineering research in this area, particularly speech research. More recently a discipline of music informatics has developed, concerned with the extraction of data from music recordings for the purposes of large scale cataloging and searching, compressed formats for transmission, 'watermarking' signals, transcription, emulative synthesis, classification and so forth. The basic framework rests upon the extraction of various 'low level features' from a signal, in both the time- and Fourier-domains (see Muller et al., 2011, for an recent review of techniques), which are then aggregated and analysed in the expectation that they will reveal 'higher-level' aspects of the sound. Such an approach runs into a limitation, insofar that, as yet, such aggregations have achieved only limited success in picking up these higher-level features, a 'semantic gap' (Wiggins, 2009).

Nevertheless, a number of the low-level features used by music informatics have become readily available in environments such as Max/MSP, so that one can, for instance, make use of statistics about Short-Time Fourier Transform (STFT) frames (centroid, slope, flatness) as crude correlates to certain auditory saliences, as well as various pitch trackers and onset detectors. The problem remains, of course, of quite what one is to do with them—which leads back to the mapping problematic above—and how reliable their results are when analysing, for instance, signals that are dense, polyphonic, noisy, or otherwise distant from ideal operating assumptions.

Much research on developing musical machines that respond to external input (as distinct from purely generative, closed systems) has maintained both

the compartmentalisation of mainstream instrument design, and the rational aggregation of low level features from machine listening. Moreover, most attention has been given to the more or less believable modelling of particular stylised responses (e.g. a 'jazz' accompanist) or interactional models (e.g. transactional turn-taking), making use of particular techniques from computational and cognitive sciences, such as machine learning, pattern recognition, or agent-based modelling, and concentrating almost exclusively on 'note-based', not 'sound-based' musicking (see Landy, 2007, for an explanation of this distinction).

All these orthodox approaches have in common that they are (quite sensibly) scientific, insofar as they seek testable solutions to well-formed, contained hypotheses, yielding generalisable and reproducible results and rational understandings of specific problem domains. However, it doesn't seem to be a given that these compartmentalised concerns should aggregate into an overall approach that is rational from the perspective of a particular musician. What the approaches of Bowers and Di Scipio share, on the other hand, is an altogether less compartmentalised, more intuitive method for constructing their musical systems, which prioritises *local* practical needs over generalised assumptions about rational human conduct (see also Ryan, 1991, 17).

In this respect Bowers and Di Scipio are representative of a more sparsely represented tendril of research in electronic music that takes a more speculative and pragmatic approach to constructing music systems. One way of positing the difference in approach is offered by Newton Armstrong's distinction between 'functional' and 'realisational' interfaces (Armstrong, 2006), inspired by Feenberg's Instrumentalisation Theory (see Chapter 2). By this account, a functional interface is orientated towards the ordered execution of a particular, well-defined task, whereas a realisational interface is orientated towards open-ended, playful encounters.

As Waters (2007) reports Richard Barrett as observing, such a realisational orientation may be taken as typical of musical encounters with technology; if one follows Suchman (2007) in locating the interface as a dynamic quality of the moments of encounter between humans and machines, rather than merely a set of designed affordances (see Chapter 2, again), then Armstrong's distinction comfortably encompasses appropriating activities such as Cage's uses of turntables in *Imaginary Landscape Number 1* (1939) or their constituent parts in *Cartridge Music* (1960), and hip-hop turntablism (Katz, 2012); the idiosyncratic approaches to electronics of David Tudor, Gordon Mumma, and Nicolas

Collins; and the intuitive approach to programming described by George Lewis in developing *Voyager* (Lewis, 1999, 2000, 1993).

It is worthwhile to stress that there is no *necessary* antagonism between these differing design orientations; the development of a 'realisational' design still involves functionalising activities as particular abstractions and assumptions are made, and even the most functional interface still affords what Feenberg calls a 'margin of manoeuvre' (Feenberg, 1999, 2002). In my own work, as I shall describe below, I have been perfectly happy to use results and approaches from more functionally orientated research in putting together open-ended systems, and it could be argued that this is generally the case. Two particular examples of making principled use of sophisticated computer-scientific approaches for exploratory ends can be found in the work of Nick Collins, for instance in his 'oppositional interactive music system' (Collins, 2010), and Doug van Nort's work using machine learning and advanced signal processing in developing his improvising system (Van Nort, 2009; Van Nort, Braasch and Oliveros, 2009). These differing approaches, then, can be complementary and productive in their difference; I have more to say about this as a manifestation of interdisciplinarity in Section 5.2.2 (p. 138).

In Chapter 2, I introduced the notion of *wayfinding* as used by Ingold (2000). This serves isomorphically, it seems to me, to the disposition that Armstrong describes as 'realisational', and also enjoys a metaphorical resonance with Sudnow's idea of 'pathways' described above. In what follows I shall offer up accounts of my own wayfinding in developing the systems included in the portfolio. Characteristic of this work is the quite purposeful absence of a cleanly compartmentalised, functional separation between 'interface' and 'synthesiser', aiming instead for what Di Scipio calls a 'structural coupling' (Di Scipio, 2003). Similarly, perhaps consequently, there is no clear commitment to the kinds of (metaphorical) paradigms offered by Robert Rowe (2001) of *instrument* or *player*; these systems might occasionally be each, or all of processor, instrument, or co-player.

For all that the systems might offer up fuzzy and unstable distinctions between components, however, the text must pragmatically introduce some categorical distinction in the interests of the wayfinding of the reader. The following, then, does observe a split between inputs and processing, as I detail the various sound sources that these systems have been developed around, and their transformation in the immediate, instrumental sense, as well as some aspects of macro-temporal processing (fuller discussion of which is presented in

Chapter 4). I distinguish between my various sound-transformational tactics in terms of *decompositions*, *residues* and *fusions*. Finally, I consider all this developmental work as one particular time-scale of practice and the (for me) sometimes uneasy shading into the time of practising in the more common musical sense.

3.4 Sound Sources and Transformations

3.4.1 Sources

At the outset—having decided that I was (for the purposes of this research) particularly interested in following Di Scipio and using 'external' sound as both material and control mechanism—my approach was to gather various objects to use as 'infra-instruments' (Bowers and Archer, 2005), and to approach the early development of the portfolio work (most especially ***There is Danger in the Air***) around motley assemblages of found objects.

3.4.1.1 Infra-Gong

Unsurprisingly, not all such objects revealed themselves as being particularly rewarding, and some were quickly discarded; others have proved more enduring. One such is the use of track-shelving brackets in ***There is Danger in the Air*** as 'infra-gongs'. I discovered, quite serendipitously (whilst putting up shelves), that variation in the sizes of ostensibly equivalent brackets leads to different enough frequencies of resonance to make for interesting dissonances and beating (Audio Example 3.1).

Uncovering a wider range of satisfying interactional possibilities, though, was a slower undertaking, not least because of a somewhat unfocused approach to exploration. Beyond merely knocking them together, I tried combinations with various other objects at-hand, such as exciting the bars with an electric toothbrush. In this sense, I was perhaps picking up on particular 'pathways' in Sudnow's sense, as given avenues in this approach to live electronic musicking around found objects. I had seen and heard electric toothbrushes and other motorised devices in use by practitioners specialising in a table-top-full-of-possibilties approach, such as Bill Thompson and Keith Rowe.

Whilst working on this initial piece, built up around a particular processing loop and a Soundfield microphone, I was also exploring this playing-of-objects and the pathways that could be gleaned through the practices of

others in freer-style, with an everything-on-the-table approach in combination with simpler processing, like loopers (Audio Example 3.2).

The unfocusedness arose, in part, from a lack of clean separation between one and the other. Early experiments with ***There is Danger in the Air*** and ***And Now For Some Music*** were marked by a somewhat fidgety approach to both assemblages and their playing, itself borne of a resistance to committing to particular resources for fear of occluding some opportunity for interesting re-combination / discovery. It took some considerable time to realise that such *unconsidered* open-endedness can itself obstruct opportunities; for instance, by just having the infra-gongs lying loose their availability for play is mediated by first having to pick them up and physically manoeuvre myself. If I want a sustained tone then this is more readily achieved by suspending them somehow—like an orchestral triangle—rather than clasping them directly, which damps them. Furthermore, if I'm using one hand to clasp, then this means it is no longer a hand that can easily be engaged in articulation. To have to repeat even a moderately cumbersome set of such moves each time I turn to them inhibits more sustained and revealing exploration. What then, is needed, for the infra-gongs to be made *ready*, as in Figure 3.1, Which, in turn presents an immediately expanded set of opportunities (Audio Example 3.3).

3.4.1.2 The Infra-Flute

Another early, explicitly infra-instrumental development, was an 'infra-flute', used in ***And Now For Some Music***. This is simply a corrugated plastic tube, sold both as a musical toy and a building material (see Figure 3.2). It is relatively easy to excite the tube, and to blow a fair way up the harmonic series (in common with more finessed musical tubes, but with less physical effort). Due, however, to its minimal approach to engineering, it is also pleasingly unstable, making getting an actual tune somewhat more difficult, especially in the lower registers. Used in conjunction with a pitch-tracker, this provides a moderately interesting way to play.

The addition of the funnel on the end came about not in pursuit of a more dispersed sound, but as a way of diffusing somewhat the amount of breath noise that emerged from the end into the miniature microphone (see below) that I use to pick up the sound, which made the pitch tracker particularly unhappy. It has the added benefit of also making the whole assembly slightly more ridiculous.

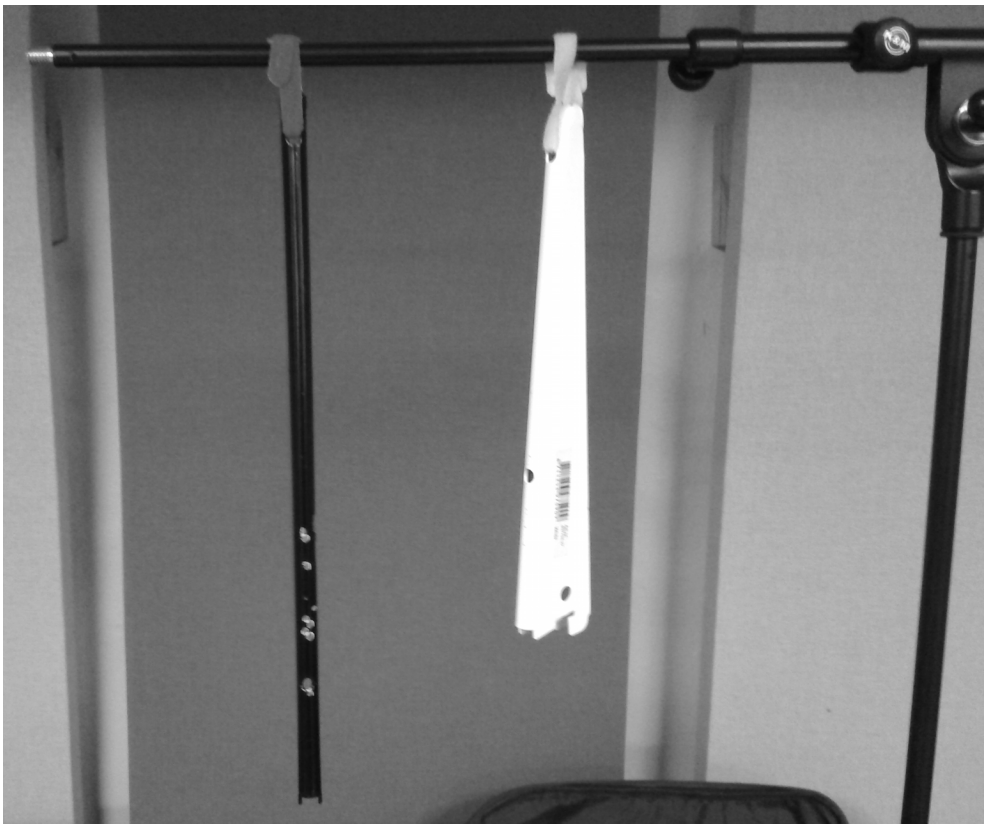


Figure 3.1: Making the infra-gongs physically available

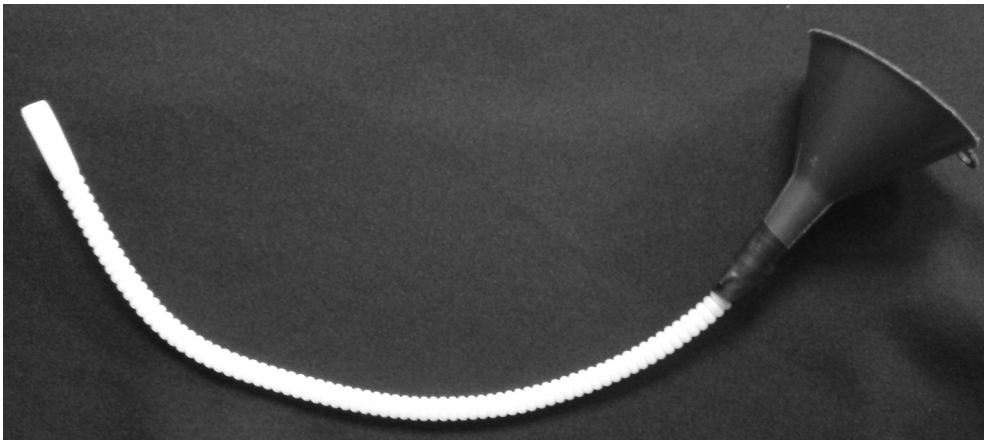


Figure 3.2: The Infra-Flute

A happy discovery with this, as the affordances of straightforwardly blowing harmonics started to wane, is that by blowing across the opening, much higher harmonics are excited, in a particularly unstable manner (Audio Example 3.4).

Whilst there is a certain amount of reward to be had in making a 'standard' pitch tracker cope with these unstable notes (which it finds difficult due to the extremes of amplitude and frequency modulation, as well as the amount of accompanying breath noise), I also started to become interested in what ways there might be of having the computer cope better with such 'difficult' sounds, such that coping with nonstationarities becomes something of a focus in the approaches to signal processing explored below.

3.4.1.3 Miniature Microphone

The miniature microphone, a DPA 4061, with which I explored the tube and other participating objects in ***And Now For Some Music*** has come to figure in my practice in all sorts of ways. Its diminutive size and omnidirectional response makes it incredibly versatile, and particularly suited for getting extremely close to sounds whilst remaining quite open-sounding.

One particular utility of this microphone is its mobility. Whereas the action of ***There is Danger in the Air*** orbits around a large, fixed and comparatively fragile Soundfield microphone, the DPA is able to be more nomadic, and go in search of action. Aside from the distinct kinds of bodily orientation this affords, being able to roam also lead to discoveries that were able to re-enter the performance ecology; whilst performing an early incarnation of ***And Now For Some Music*** at City University in 2006, I had extended my roaming range by using a particularly long XLR cable. At one stage, where I felt the need for some kind of rupture, I had enough scope to approach one of the front loudspeakers and play upon a more direct re-circulation (the piece has a long, and heavily mediated delay in its processing loop, so the effects were highly non-linear recapitulations, rather than Larsen-squeals). This was effective, and a loudspeaker was then made part of the more local performance ecology for this purpose.

Another 'pathway' that was presented to me was Di Scipio's optional use of a 'mouth performer' with a DPA miniature capsule in *Background Noise Study* (Di Scipio, 2011). Whilst I started out mimicking his approach in the microphone-as-microscope tradition to amplify minute, almost ancillary sounds from the mouth, the combination of mouth and miniature microphone

has turned out to have all kinds of other uses, not least because it is extremely tolerant of becoming wet (it will simply cut out for a short while if too wet).

One use, then, has been to use the mouth-mic combination as a control signal source. For instance, when playing sample-based music in Ableton Live (as in ***Exchange Value***), using this signal to key a gate provides both a way of articulating samples, and also of playing rough textures, depending on settings, whilst the hands are free to do other things (Audio Example 3.5).

Meanwhile, in ***Spectral Dweller***, mouth and microphone are enrolled in both a control sense and in the audible-probing sense, as the microphone is used to find interesting areas of turbulence around the mouth, as well as disturbing sounds from inside (Audio Example 3.6).

3.4.1.4 Voice

Combining mouths and microphones leads one to consider voices. Where my voice does appear, then the habit for it has been to be heavily shrouded by processing, and to veer well away from singing-as-such. Around 2009, I started to make more general use of my voice when playing 'privately' with friends, and in improvising ensembles, and (with the slight help of some earlier singing lessons) had started to get over my post-adolescent-boy embarrassment at my musical voice. I hadn't really expected to roll this out in public at any point, but agreed to do so when asked by my colleague Sean Williams, for his piece *Electronic Skank* (Video Example 3.1, vid_3_1_SWilliams_Electronic_Skank_edin.mov).

These same vocal techniques are in evidence in ***Spectral Dweller***, but considerably more heavily mediated, which stems, I am sure, from a continuing, residual embarrassment about the use of voice. I raise this for two reasons.

First, it allows me to cheerfully acknowledge an inconsistency on my part, in that I seem to feel differently about the role of skill and technique for voices than with other technologies I have explored musically. In the other examples presented, I have been happy to make the wayfinding a public affair (perhaps on the basis that there were no real grounds for doing it wrong), whereas I often find it hard to think of my vocalising as much other than low-rent homage to Mike Patton, Phil Minton or Joan La Barbara. This brings notions of skill and technique back into our consideration, and it is worth noting that the earlier fidgetiness of my first forays across the infra-instrumentscape began to settle

down into more prolonged, even slightly systematic at times, engagements, where I would try out similar things in numbers of different contexts.

Part of the reason that voices are perhaps special in this regard is that it is particularly evident when the voice is used with a lack of *commitment*, given that we are particularly sensitive to the nuances of human vocal production (Wishart, [1985] 1996). As a loosely formed aesthetic preference in witnessing other people's improvising, I am using 'commitment' as a shorthand for a slippery combination of the timeliness and stridency of sound production; there is something about its absence that I sometimes find quite alienating, all the more so when a voice (mine or someone else's) is involved.

Second, and in turn, it allows me to point to a perhaps under-analysed aspect of electronics-as-mediation as a kind of armour, or at least a defensive posture to be adopted in musicking and, especially, performance. I pick this idea up again in Chapter 4.

3.4.1.5 Cardboard Box and Bow

I originally approached the box, bow-in-hand, with high (or perhaps low) expectations of its infra-instrumentality. I didn't anticipate that it would yield much more than undifferentiated shrieking, and intended that it should form the basis of a duet with a 'real' stringed instrument, with a real player for a computer-mediated pantomime playing on themes of competence in both playing and lutherie. It was something of a surprise, then, that the shrieking turned out to be altogether more differentiated than I anticipated and that, moreover, the box and bow revealed themselves amiable to prolonged exploration, although if I'd been aware at this point of the precedents set by others, such as Iannis Xenakis in *Orient Occident* (1960) and Pedro Rebelo in *Rust* (2005), I would have been less surprised.

In the first instance, the 'pathways' available to me were simply concerned with more or less successful sound production. Save for a very brief flirtation with the cello as a child, which was interrupted by breaking a leg, I had no real experience with a bow, and the cardboard was not always inclined to sing. Reasonably swiftly, I was able to more or less reliably produce either steady(ish) tones, or more turbulent textures (it should be noted that the steady tones still exhibit a great deal of frequency modulation and only approximate harmonicity). This was followed by a quite rapid expansion of sound colours, as I was able to grasp the cardboard lip of the box (my 'string') at different points relative to the bow.

Figure 3.3: Playing the Cardboard Box, Inspace, Edinburgh, 2010. Photo by Martin Parker.

At this point, I remained in an area analogous to Sudnow's 'pathways'; I had a forming notion of the terrain, and certain set pieces I could hop between, albeit not always successfully. After an initial performance of ***Cardboard Cutout***, I spent more time with the bow and box, but without the electronic augmentation, as it was beginning to offer up increasing possibilities, and moreover afforded a degree of timeliness I was finding frustratingly absent from my various electronics. I started playing the box a-cappella, as it were, both with the large scale EdImprov ensemble, and with the ensemble discussed in Section 1.1.3 (p. 40).

This spell of unplugged musicking turned out to be quite valuable. For one thing, I was able to develop some ways of attending to collaborative goings-on, now that my attention was no longer partially orientated to the symbolic world of the computer; happily, these seem to come back with me to the computer, so that I felt a palpable improvement in my electronic co-musicking

also. Moreover, the box seemed to keep 'giving': I soon found myself, again following Sudnow, able to 'go for sounds', that is, to orientate myself moment-to-moment towards an intentful making of a given sound, rather than a plan-aim-hit/miss sequence characteristic of earlier stages. This in turn opens up a music that can be gone-for, a voice increasingly capable of significant 'sayings' (Sudnow, 1978).

Aside from ready replaceability, one particularly pleasing feature of the cardboard box is the pronounced way in which it bears the traces of its use. One box, in particular, I have stayed with for a couple of years, and as its lips have frayed, so its tone has mellowed somewhat and the terrain it presents has gently shifted. This infers a kind of comfiness and reciprocity which is pleasingly symbolic.

3.4.2 Tracings, Deconstructions

Presented with a preference for these highly non-stationary kinds of sound making, another component to the work has been to find ways of computational hearing that are sympathetic to their peculiarities, that get (more or less literally) at their 'grain', and that adapt (in some desirable way) to changes in the sound.

My earliest efforts in this direction were conditioned somewhat by the fidgetiness I describe above. On the one hand, I was engaged in trying to reverse engineer Di Scipio's *Audible Ecosystemics*, initially on the basis of correlating an incomplete segment of flow chart (Anderson, 2005, 14) with the kinds of features Di Scipio described as being extracted (Di Scipio, 2003, 5), alongside a more concrete (but apparently simpler) example given as a Pure Data patch (Di Scipio, 2006). Di Scipio seemed mostly to be relying on envelope followers to generate control signals, and extensive post-processing of these signals to drive his adaptive systems. What eluded me was quite how the connection between these signals and perceptual inferences was being made.

On the other hand, there were Max/MSP objects available that would immediately give me more features, such as the 'analyzer' object based on the PhD work of Tristan Jehan (2005); more features, I reasoned, must yield richer behaviour, surely? It seemed to me that by scaling up the approach to 'adaptive digital audio effects' developed by Verfaille, Wanderley and Depalle (2006), I should be able to arrive at Di Scipio-esque adaptivity.

However, given the somewhat diffuse way in which I approached initial work, on both ***There is Danger in the Air*** and ***And Now For Some Music*** in particular, what this actually yielded was something of a mess. Besides running into problems about how to best handle the routing and management of this mass of data in Max/MSP, what I ran most significantly into was the same 'semantic gap' described above. It took me quite some significant time to appreciate that for both Di Scipio's approach of deriving information from simple energy envelopes and the mainstream approach of more direct measures of ostensibly perceptual attributes from a sound signal, making any sense of these required some more specific assumptions to be made about an eventual context in order to be able to match up a change in a feature to an indicator of particular action. For instance, if you design around the assumption that the incoming audio signal is, say, someone playing a clarinet, it is possible to then make a series of inferences about what, say, an increase in spectral flatness ('noisiness') might imply in terms of a player's activity.

Similarly, Di Scipio is able to make inferences from his envelope followers because the context in which their changes occur are taken as given. For instance, in *Background Noise Study*, events are detected by tracking the movement of an envelope in relation to a static threshold. In the general case (for an arbitrary signal) this makes for a highly unreliable correlate of how we might perceive audible events as occurring. In the specific context that *Background Noise Study* is designed around, where the broad types of sound and their behavioural likelihoods can be anticipated, it serves perfectly well. Moreover, because of the way the resulting measure is employed, its approximate nature is not only unproblematic, it is profoundly useful for Di Scipio's embrace of inherent system 'noisiness' as an animating principle (Anderson, 2005).

My fidgeting, manifest in fluttering amongst my arrays of infra-instruments, however, was not proving effective. This initial resistance to commit, to approach things manageably meant I was not, as was my conceit, getting closer to a 'realisational' interface by courageously refusing to make any modelling assumptions, but, in effect, trying to achieve a grand 'functionalisation' by making an *anything-processor* without any reference to a situating context. Finding my way out of this contradictory and profoundly unproductive position has been (is?) at times slow-going; the nice thing about *finding* a way, however, is that one gets to pick one's own landmarks.

3.4.2.1 Decompositions, Residues and Fusions

Dissatisfied with the kinds of result I was finding myself able to achieve by using these standard descriptors as drivers of processing, I started to look further afield at emerging forms of analysis geared towards non-stationary signals. Whilst I was unable to find any generalisable solution (although Doug Van Nort has been doing some very promising work with an adaptive technique called Empirical Mode Decomposition (Van Nort, 2009; Van Nort, Braasch and Oliveros, 2012)), the process of conducting a broader survey into signal analysis, in concert with a more systematic and practical investigation of the rationale behind Di Scipio's work (see Chapter 1), has yielded a broad collection of approaches that can be seen in the portfolio work.

The first of these is in terms of *decomposing* signals. One aspect I was after was to be able to cope effectively with noisy, tonal or transient behaviours. The default approaches in much electronic music of using the Phase Vocoder based around the Short Time Fourier Transform (STFT) is problematic in this regard, as there is always a trade-off to be made in its effectiveness in either time or frequency, it exhibits significant latency for longer analyses, and I am not particularly fond of the sound of its artefacts. In ***And Now For Some Music***, I use a time-domain pitch tracker based on the Pitch Synchronous Overlap-Add approach (Zölzer, 2002) to (quite approximately) segment a signal into 'pitched' and 'noisy' frames, so that they can be dealt with separately. In ***Cardboard Cutout***, I use a couple of more involved techniques. One also makes a distinction between noisy and pitched material, but this time by using non-linear filtering of STFT frames, based on a pleasingly simple scheme by Derry Fitzgerald (2010). The other also features in ***Spectral Dweller***, and uses a small bank of adaptive filters to track peaks in the signal, based on a design by Kumaresan, Peddinti and Cariani (2012), and then uses the amplitude and frequency modulations in these narrowband signals for driving transformations based on their 'instantaneous complex frequency' (ICF) following Kaniewska (2010).

The second approach has been to try and take advantage of *residues*, to value the noises and 'imperfections' that signal processes bring with them. For instance, ***And Now For Some Music*** tries to make creative use of the disagreement between two different pitch tracking algorithms in conceiving of a computer 'response' to goings-on. ***There is Danger in the Air*** uses a quite deliberately oversimple method of inter-channel relationships to try

and distinguish between human and computer action; the ICF transformations in ***Cardboard Cutout*** are highly contingent upon the reliability of the modelling assumptions behind the decomposition, which are themselves available for playful disruption, and the mis-tracking of STFT peaks can make for interesting dissonances; in ***Exchange. Value*** two different methods of inferring tempo, both of which are only moderately sensible[1], are used to propel temporal disruptions; ***Spectral Dweller*** features a range of idiosyncratic approaches to combining and extending input signals, most notably the only approximate attempt at spectral modelling used.

The final broad approach is *fusions*. In the solo pieces, this is mostly to do with the cultivated ambiguity between the functional boundaries between processor, instrument and co-player. My practice in all of these, for instance, is not to feature a static mix of 'dry' and 'wet' signals, but to try for a more dynamic situation that disrupts a stable display of causality. In the two ensemble pieces, ***Spectral Dweller*** and ***Exchange. Value***, I am concerned with the idea of 'the instrument' as a distributed system. ***Spectral Dweller*** was conceived as a 'solo for two' (though of a different sort to Grisey's *Solo Pour Deux* (1981)); in order to excite the system, there must be co-action, and messy attempts at gauging the degree of coordination influence the result. In ***Exchange. Value***, a system of three laptops is tied together, following the kinds of work done by The Hub (Gresham-Lancaster, 1998). Audio is shared around this small network (although with no obligation on players to make use of it), affording a variable terrain of distinction / homogeneity of the contributions from individual players. Besides sharing streams of audio with each other, a loose coupling is established that gauges relative amounts of activity, which contributes to decisions made by patches on each performer's machine about whether or not to pass sound. The idea here is that the fusion should be integrated into the experience of the players by making the autonomous aspects of the system contingent on a reading of collective, physical action.

3.5 Practising Practice

Compared to the weight of research activity that examines the *design* of systems for musicking, there is curious silence on the issue of *practising* as something more substantial than a ripple between design and public performance.

[1] One is to infer tempo from the rate at which MIDI messages are triggered, using this as an indicator of physical activity. The other uses an onset detector that prioritises speed over accuracy, using a somewhat dubious time-domain technique for detecting transients.

However, one suspects that there is much of interest to be found in the various approaches to practising of electronic improvisors, particularly using systems they have designed.

This is in significant part due to the conspicuous fluidity that computer based systems can present, particularly in environments such as Max/MSP, or Supercollider, CHucK et al, that afford immediate reconfiguration. This in turn means that they afford endless tinkering that, itself, can be quite destabilising.

Beyond noting some of the central questions that can be raised about this—in order to briefly examine the often turbulent and indistinct transition from building to practising that has been apparent in this research—I shall not be attempting a more thoroughgoing theorisation. Such a theorisation would, I think, be apposite and fruitful for a number of reasons. First, it is a question that practice-led research is uniquely well positioned to confront, and informal discussion with colleagues suggests that it is widely experienced as a vexatious issue. Second, if a pedagogy of this type of musicking is to establish itself, then it would be helpful to have something coherent to impart to students about practising that nonetheless respects the vibrant idiosyncrasy of approaches that are peculiar to it. Third, the complex foldings between designing and practising a musical system have interesting potential for interdisciplinary valences, for instance in communicating to HCI researchers reflections around complex patterns of use and experience possibly quite distinct from the kinds of linear goal orientation that may be associated with more general tasks, or in making available to ethnomusicologists and sociologists of music data on how, where, with whom the incubation of these musical practices takes place, that could help orientate their own research (see Section 5.2.2, p. 138, for further discussion of interdisciplinary relationships).

It should be noted also that there is a significant degree of crossover here with questions surrounding what it means to practise improvising in a more general sense. Given the widened perspective of what constitutes an instrument presented in Chapter 2, we should expect a degree of contiguity between electronic and acoustic approaches, particularly around those acoustic practices that adopt exploratory approaches to already established instruments. In either case, the kinds of 'pathways' discussed by Sudnow are more likely to be things found than given, and there may well be a complex, knot-like relationship between finding and enskilling, rather than a clear sense of onwards progression.

Some starting questions, then, might be:

- How are we distinguishing design work from practising, if at all?
- Are we conscious of when we are doing one or the other?
- Do we have strategies or tactics for managing these circumstances?
- *What* do we think we are practising?

With respect to the first question, there are a number of different dispositions towards a system that I can identify. Coding activities may, at times, be soundless, as—per standard programming practice—functions are developed and tested against input that should yield particular output and mistakes are tracked down and fixed in an iterative debugging cycle. This would seem, unproblematically, to constitute a designing activity. Programming work may often be soundful, of course, as systems and sub-systems are tickled with sound, and a certain amount of critical listening to the results is performed. Here a fuzziness of activity is possible (maybe unavoidable), as whether or not this is regarded as design or practising depends very much on a conscious orientation towards one or the other.

My experience has been that this can be a particularly perilous area, as somehow one has to lift oneself out of a orientation geared towards problem-solving (how do I do x?) to something orientated towards musicking, which implies a certain amount of *coping*. In solo settings, especially, I have come to notice a range of micro-pathologies in this respect. Mostly, these concern a sort of fidgetiness that can then ossify into a particularly un-musical disposition to the task at hand. For instance, whilst considering myself still to be coding / problem-solving, my enaction of soundful testing might consist of short bursts, quickly interrupted if I am unsatisfied with the immediate outcomes. If unchecked (and it is so often unchecked), the result can be a lengthy, counter-productive fixation on some very small problem that defers a full-blooded engagement in which the small problem might well not only turn out to be liveable-with, but productive or suggestive in some ways. Even in lengthier, bloodier engagements, there is a transition in listening-to-the-patch and listening-to-the-music that can sometimes take quite some time to resolve, and, again, sometimes leads to unconsidered tinkering, which serves to delay this transition further. It can be easier in collective settings to orientate oneself to the idea that now we are practising, but even here, the transition has

to be negotiated: systems made with particular co-actions in mind are really only able to undergo serious exercise in a collective setting, so that a delicate balance needs to be achieved between the momentum of rehearsal and an unavoidable need to attend to patches[2].

Methods for coping with these problems, insofar as I feel myself to have arrived at any, have arisen *ex post* and only when I have granted myself the space to try and reflect upon them, rather than hurrying back to the next pressing micro-problem with a patch. If one is to accept a certain degree of haziness in the specification of a particular system, particularly when it comes to developing behaviours at longer-than-immediate time-scales (see Chapter 4), then there is a corresponding issue of knowing when things are as finished as they are going to be for the time being, and that activity should now be centred around learning to find music with what there is; indeed, a consciously managed transition from the *grabbing* that has concerned the discussion of this chapter, to the *holding on* explored in the next.

In part the trick to this would seem to be cultivated discipline, approachable in a number of ways. One could, for instance, just set time limits to developmental phases, or fuzzy yet identifiable milestones, beyond which one commits to just coping. Alternatively, one could consider the sizes of design changes in respect to the amount of musical working through they get. This is certainly what I regard as my recurring stumbling block: a sequence of tweak-fidget-fidget-tweak-tweak-tweak, for example, can quite quickly result in radical changes to a design without having taken the chance to become knowing of the intermediate stages. From a musical point of view, it may be that committing to a full day's concentrated play *for each tweak*, for example, turns out to be considerably more fruitful in the longer-run, however much it might feel like it is holding up goal-directed development.

Of course, it may be that there simply is not a thing that can be played for a full day, because the system is still nascent or inoperative, or one simply can't bear to be in the same room as it at that point. The question of what it is that one might consider oneself to be practising can be a useful point of reflection, especially if the alternative is slinking back to the computer to focus on a micro-issue. In this respect, my prolonged engagement with

[2]In the case of the two ensemble portfolio pieces, ***Spectral Dweller*** and ***Exchange. Value***, I ended up implementing special 'one-player' modes, partly as a coping strategy for working with otherwise very busy co-players, and partly to help ensure that participants could get more musical exposure to the systems between rehearsals (to the extent that this was possible in the absence of the various cross-coupling mechanisms the pieces rely on).

bowing cardboard was particularly revelatory, given that I do not have an instrumental practice as such; having something that I could just pick up and play afforded working on a range of more general skills, besides any increase in technical facility with the box. Similarly, the various activities discussed in Chapter 1, such as approaching pieces by other composers, and finding places to play collaboratively, unsurprisingly feed in to a more general mix of skills.

Reflecting on what it is we do in practice sessions is particularly worthwhile because it can prompt us to consider how to approach aspects of play that might resist straightforward practising. For instance, in a rare discussion of practising in live electronics, Nick Collins (2007a) outlines possible practice strategies for honing specific aspects of live coding. Furthermore, there is a range of apparently ancillary issues that turn out to benefit from a practised approach; what happens for example, when your patch with live microphones finds itself in a loud performance environment, with untamed acoustics? How does one cope with the uncanny proclivity of music technology to misbehave on stage? How do we manage relationships at these times, such as with sound engineers? Such issues constitute aspects of a performance practice (or at least a pre-performance practice) which, along with the peculiar time that is performing, I consider in relation to my own research in the following chapter.

3.6 Summary

The processes of developing environments and practices for live electronic improvised music overlaps characteristics of musical learning and technical design. My concern here has been to trace aspects of how the portfolio pieces came to be rather than to comprehensively describe their current feature-sets as an accomplished fact. Taking my lead from Sudnow (1978), I have offered a diachronic and critical account of the *practice* around this development, in order that I might highlight certain aspects deserving of further discussion.

First, I have offered an argument about how this development has departed from orthodox engineering practice, contextualised by the discussion of wayfinding in the previous chapter. This affords a perspective that is not needlessly oppositional—for instance by presenting artistic design as wholly distinct from standard engineering practice—but instead is able to pragmatically note the intermingling of the orthodox and the deviant. Second, I have been able to trace the forming of aspects of the portfolio pieces in more sophisticated and, I hope, frank terms than as the pure outcome of compositional

intentions. Rather, I have been concerned to note the ways in which my shifting proclivities and the various personal and technical resistances I have encountered contribute to what the pieces have become.

The value of this approach, it seems to me, is that it offers a material and pragmatic basis for further exploration of the ways in which the design of musical systems is distinct from general engineering that can contribute to a wider disciplinary discussion on how we—as practitioners, researchers and teachers—conduct ourselves individually and collectively. The issue of practising as something phenomenologically distinct from coding emerges as a core issue here, and presents a fertile area for further research along these lines. In the following chapter I continue this examination of how practical contingencies have shaped the development of the portfolio pieces, but shift the frame now from the 'grabbing' of conceiving and designing to the 'holding on' of performing.

Chapter 4

Holding On

4.1 Introduction

Moments of performance, and the halos of time surrounding them are of profound significance to the shaping of a practice, not least since public performance of certain particular sorts is taken to be the obvious locus of musical doing. The focus on public performance can serve as a sort of gravity well, both in discourse and in practice, for instance in the way that practising morphs into rehearsing, which can be a very different kind of activity.

Rather than rustle up a theorisation of performance-as-such in which to try and situate my practice, I want to continue here the tracings of the last chapter to explore how the portfolio pieces have been shaped by their own early public performances, and by my experiences of performing more generally over the course of this research.

These experiences are approached in terms of my bodily orientation during performance; the ways that experience of performing folded back onto my approach to time in the portfolio pieces; coping with loudspeakers and sound engineers as an integral part of the instrumental ecosystem; and the distinct interpretative games of different performance sites (Shusterman, 2002, see also Section 2.3, p. 83).

4.2 The Multiscale Rhythms of Performance

Performing serves as a punctuation in practice, a discontinuity. Whether it is an infrequent occurrence, or whether one is in the midst of a gruelling tour schedule, a performance becomes a locus for intensive preparatory work:

travelling, waiting, setting up, and so forth. Much as Peter Nelson (2011) locates a social ecosystem of musicking around the punctuation of rhythm, so the longer and varied rhythms of activities surrounding performance can serve as markers of different but overlapping socio-musical ecologies (Mayr, 1989).

So, the amount and patterning of rehearsal; the nature of loading in and setting up; the times and places in which waiting occurs (and how one learns to cope with this time); the speediness with which one must vacate the stage and / or premises, all vary slightly but significantly between social ecologies and indicate much about the relationships and priorities of those involved.

The 'moment' itself, of course, is not a singularity, but has *duration* as an expanse of lived time. However, the phenomenal qualities of this duration—the livedness of this time—are quite distinct from when I am *grabbing*. Even in practising, when a performative orientation has been adopted, there is often only a semblance of the peculiarity of performed duration as concurrently dilated and contracted, where one can do simultaneously total focus and total abandonment.

As such, there is a quality of *noticing* that is peculiar to performing that yields different insights to what one's doing than are otherwise available, and that feeds back into practice in distinct ways.

4.3 Bodies, Movements, Stances

> It is perhaps a general human habit to view the technological and the organic as opposites. It is certainly the case that the phrase 'live electronic music' strikes many a music fan as oxymoronic. Isn't the purpose of electronics to do things for us so we don't have to do them 'live' ourselves? (Collins, 2007b, 38)

Nicolas Collins is, of course, being rhetorical above, given his long commitment to live electronic performance. However, he captures nicely what is widely regarded as a central tension in the performance of electronic music, between automation and notions of performative authenticity, variously explored through 'effort' (d'Escriván, 2006), 'presence' (Emmerson, 2007) and so forth. This becomes particularly acute when a laptop is involved, and as such an oft-heard (and so somewhat wearisome) tease that 'you could be checking your e-mail for all I know' is, in part, a signifier of genuine anxiety on the utterer's part about what to make of a person apparently just staring at a screen. One response to this has been to highlight and make a virtue of the disruption of standard performative expectations this entails; both Kim

Cascone (2003) and Kaffe Matthews (Emmerson, 2007) position this orientation in terms of changing the interpretative game to one focussed more wholly on an aural engagement. There is, of course, a significant counter tendency in live electronics, particularly associable with artists that have been at one time or another affiliated with STEIM in the Netherlands (Ryan, 1991), that is concerned with approaches that afford a more apparent and performed physicality of, nonetheless, idiosyncratically electronic music.

The approaches I have taken over the course of this research towards my stance in relation to my laptop, and to the physicality of my musicking have been varied, yet all conditioned by experiences of performing. The dominant, but not universal, tendency in the portfolio pieces has been to step out from behind the screen, and to try and minimise any time spent looking at at. ***There is Danger in the Air*** and ***And Now For Some Music*** both represent small steps, as I shuffled at first slightly grudgingly into view. These shuffles were made on the basis of my experiences with early versions of ***There is Danger in the Air***, and were born not so much out of a concern for the dynamics of my social presence vis-a-vis the audience (I am afraid it took a while for awareness to develop on that front), but of the pragmatics of having my attention divided between the ecology of objects with which I was still fidgeting (see Chapter 3) and shepherding the computer into different states.

The laptop, then, was put to one side, and the locus of bodily action centred on the Soundfield microphone that serves as 'ear' and interface, with a table full of my sound trinkets sometimes between myself and the audience, sometimes off to one side, depending on the contingencies of stage cohabitation. In ***And Now For Some Music***, I had a similar kind of assemblage of objects, but a significantly different ecology as these were being explored with the more mobile probe of a DPA 4061 miniature microphone, rather than being moved *to* a fixed microphone. This, then, also involved a table, but more often in front, and with me seated behind. In fact, this ecology gave rise to some of the same problems as 'pure' laptop performing, as my movements tended to be smaller, and focused down on to a plane that was not available for co-inspection by audience members (in a sit-down-and-stay-there kind of setting at any rate, although one could in principle solve this with an overhead camera). These early shuffling moves, first from behind the computer, and in some cases from behind a table began to make apparent that the computer especially, but also the table to a lesser extent, can serve as a protective shell from feelings of exposure when performing. It is quite

possible to perform on a laptop and become somewhat oblivious to the fact of being under a collective gaze, as the uplighting from the screen blinds you to the space outside its nimbus and invites absorption into its illuminated, symbolic world. To be stripped of this was vaguely traumatic at first, and I would find myself at a slight loss, unable to let silences hang, feeling that I ought to be *doing something* at any given moment, lest all these suddenly appeared looking-people felt I wasn't making an appropriate effort.

Nevertheless, the portfolio features two further pieces in which the laptop's screen is not attended to. In ***Cardboard Cutout***, bodily activity is wholly concentrated on the literally and figuratively cheap trick of playing the cardboard box. I have tended to sit for this, perhaps unconsciously aping a cellist, but this wouldn't seem to be essential, and sitting is not without its awkwardness. If I am on a normal height chair and the box is on the floor, the action is all a bit hunched, not to mention uncomfortable, as is trying to hold the box between the legs like a cello (which also tends to damp its limited capacity to resonate). One could join it on the floor, but besides my knees not being what they used to be, this again produces a heads-down, curled up, armadilloesque posture and seems to give reduced scope for movement. Alternatively, one could place the box on a table and stand behind it, but this again feels as if it makes a wall between the audience and me, and if the table is too high (I am quite short), makes necessary an uncomfortably elevated shoulder posture. So far the optimal set up has been to remain seated and use a short speaker stand.

In ***Spectral Dweller***, an emphasis on co-action and mostly very quiet playing means that that I and my co-player tend to be arranged quite close to each other in order to hear and see. The 'spectacle' is on the one hand of one player being broadly conventionally instrumental in gesture (with a flugelhorn, albeit with microphones in strange places), but not necessarily in sonic response, and of less immediately recognisable action on my part, as I probe around my mouth with a miniature microphone.

Conversely, the approach adopted in ***Exchange. Value*** does remain behind the screen. In this it is reflective of the fact that this orientation still crops up in my wider practice a good deal. For instance, in one collaborative project performing improvised hip-hop as part of the duo *Sileni*, I have been actively hesitant about emerging from behind the screen, as there is a pleasing contrast between a slightly cultivated intentness and stasis of my stance and the physical presence of my MC collaborator, Ali Maloney, whose practice in

physical theatre contributes to a highly developed dynamism and occupancy of the performance space.

Similarly, the trio for whom ***Exchange. Value*** was conceived has approached the problems of laptop performance from 'the other side', by seeing what we can do collectively using standard software (Ableton Live) and controllers (see section 1.2.1, p. 45). Our performance ecology, then, is a sort of hedge of consumer electronics between the group and the audience, particularly as in performance we tend to be allotted space by promoters on the basis of playing in a dead straight line on a long table 'DJ style', although when we rehearse we are as likely to orientate ourselves in a loose circle. Because of both the screen-gaze and gestural dislocation, there is ever-present ambiguity for audience and players alike about the provenance of any given stream of activity. ***Exchange. Value*** tries to simultaneously inflate the sense of instrumental co-identity by linking the machines in various ways (see Chapter 3), and develop a tighter bonding to stance and movement by linking the individual 'voicing' capabilities of each participant quite intimately to the *quantity* of physical movement they seem to be putting in.

4.4 Continuations, Interjections, Responses and Non-Sequiturs

> "... drop a silence bigger than a table..." (Leo Smith, quoted in Lewis, 2008, 243)

Much of the work that has gone into trying to develop and form the behaviours of the portfolio pieces over longer timescales has been shaped by the experiences of performance. In this part this is due to the different quality of durational experience that obtains while performing; making judgements about the translation between the absolute time of the computer and the durational unfolding on stage is intensely difficult, if not impossible, to approach in a formalised way (Plans Casal, 2008) and the pragmatic solution is to try and approach this through an iterative cycle of reflection and adjustment.

Another aspect to this is that the circumstances of performance frequently give rise to radically different, unforeseen behaviours where microphones and loudspeakers are involved. Rehearsal and practising often, by necessity, take place in smaller spaces, with smaller loudspeakers and more moderate sound levels. The profound differences in sound field that can arise in performance situations can sometimes have quite surprising effects. The issue of loudspeak-

ers as a particularly variable, yet vital terminal point is considered further below.

As devices that can sustain sound indefinitely without correspondingly sustained physical input, computers readily afford what Hazel Smith and Roger Dean call 'continuous-stream' improvising (Smith and Dean, 1997, 67). My general trajectory over the course of this research has been a movement away from continual streaming towards to make more use of silences and variations of density, and to imbue the portfolio pieces with more dramatic behaviour in that respect. This movement on my part has been formed by a gradual appreciation that whilst there is something perfectly satisfying about continuous streams in the *musica-practica* of playing as a way of simply being together, and in certain performance circumstances (parties and dancefloors, for instance), the attentional disposition of the sit-down-and-stay type of performance made it much harder to maintain a sustainable degree of *tension* (at least for me, and there didn't seem to be much point making a performance that I got bored in the middle of!).

The first significant public outing of ***There is Danger in the Air*** (at the ICA, London in 2006) is a case in point. Having difficulty in mimicking Di Scipio's ways of working, based on limited information and understanding, I was unable to make something that exhibited enough variation in its continuous stream to keep me satisfied, and didn't yet have the performative chops to cope with this at my end. I had resorted instead to having a set of incrementally different settings that I could cycle through at a button push to nudge the system into new states. Given a basic structure of a longish feedback cycle, these stepwise changes tended to get smoothed out somewhat in practice. This continued to be the case in sound check also, despite my situation on stage being nestled in the midst of a not inconsiderable number of loudspeakers being used for the diffusion of acousmatic pieces also on the bill. When it came to my set, however, what I now know to be almost an inevitability had occurred, and the sound engineer had increased the levels significantly between sound check and performance.

The following ten minutes were an interesting lesson in coping with the contingencies of performance: the patch immediately hit the rails and glued itself stubbornly to an equilibrium of merzbow-esque distortion, and exhibited a stubborn unwillingness to be shifted by sound-making on my part (Audio Example 4.1). Reducing the input gain, whilst changing the quality of the distortion, didn't solve the latter problem which was to do with the relative

levels of loudspeaker and physical action into the microphone, and a kind of on-stage stupefaction meant that lowering the output gain instead didn't even occur to me; in the end the only thing available (short of throwing an actual tantrum) was to re-conceive the piece on the fly as a percussive interaction of shelving brackets and the microphone stand (I wasn't quite annoyed enough to start hitting the microphone that hard). The various different sections I cycled through only exhibited minute perceivable change, and the end result was a unbroken 10 minute monolith.

The following performance of ***There is Danger in the Air***, at the University of Edinburgh in 2008, was also marked by the system settling stubbornly on an equilibrium, though with less drama—here I was setting up the sound system myself, so less liable to be surprised by changes in level, and had taken some steps to make things more robust. On this occasion we (the system and I) got locked into a call and response loop where all input material was getting resampled down, and down, and down as it recirculated through the environment and back into the microphone (Audio Example 4.2). Like the wall of noise experienced at the ICA, this was not an awful thing in and of itself, but it wore thin in the unplanned predictability of response and resistance even to modulation, let alone dramatic change.

Concurrently, I was having similar difficulties with ***And Now For Some Music***, in that the computer response would build up some quite nice undulating textures, and there was a more pronounced counter-point between my 'local' gestures and the 'field' of computer sound (Emmerson, 2007), but I still hadn't yet devised articulations at longer time scales such that the textures would start to exhibit a sense of something more rhythmic. Neither was ***And Now For Some Music*** immune from its own performance-time surprises. At the same show at the University of Edinburgh in 2008, whilst everything had behaved as well as I could have hoped in sound check, the whole performance was dominated by a chopping effect that turned out to be an unexplained and un-reproducible significant rise in CPU usage[1] (Audio Example 4.3).

Changes of behaviour in the performance space have not always been a source of consternation, however. The portfolio version of ***Cardboard Cutout***, that I performed as part of Dialogues Festival, Edinburgh in 2010, attempted to provide more of a dynamic surface to play against by modulating

[1]The proclivity of music technology to develop special, never-before-seen faults at or around performances sometimes makes it tempting to take the idea of machinic agency altogether literally.

the mix and ordering of different treatments, as well as having some slightly mono-temporal automatic gain control to stop unexpected explosions, which a hastily condensed development-rehearsal cycle had produced plenty of. One of these treatments drives a filter bank based on the stationary components of the incoming spectrum; this, of course, meant that in the more-amplified and acoustically lively performance space, the whole electro-acoustic system would latch (almost gleefully) into feedback. However, the automatic gain control would slowly grab hold of it (and other processing would interfere) such that, blessed as I was with a trusting soul doing front-of-house sound, I was able to let the occasional swells blossom up as strident punctuations from the machine, and serve to contribute to the rhythmicity of the performance.

In a related manner, it has sometimes been the case that mechanisms have worked better in performance than I had anticipated. This is, I think, partly due to the different qualities of attention at work between development, practising and performing. For instance, a performance of a prototype of ***Exchange. Value***[2] yielded some more modulations of density and temporal congruence than I had expected on the basis of either my listening-while-patching, or of the trio's ability to cope with the system in rehearsal. In this instance, the code was not behaving any differently, but we were considerably more focussed in our responses to the systems interjections as a consequence of being given over more wholly to our playing.

The eventual technical mechanisms I have arrived at for dealing with macro-temporal aspects in the portfolio are shared across a number of the pieces, and can be split into two broad categories. The first is the finding of pulses, albeit in a non-standard manner. The second is to strategically inhibit the rate at which certain aspects of the patches respond to changes in circumstances. The pulse finding mechanisms are most widely used in ***There is Danger in the Air***, ***And Now for Some Music*** and ***Exchange. Value***. In the first two, I developed a patch (called `otg.wobblypulsefollow~`) that differs from orthodox beat tracking insofar as I am not interested in finding a single tactus that is used as a top-down clock, but in finding a number of different *plausible* time-scales, on the basis that improvised conduct will tend to yield a number of these and that there is no particular reason to assume that they may be metrically related in any simple way. In other words, I am more interested in having the computer's contribution be *timely* than I am in having it arrive on some putative beat. A further embellishment to this, in

[2] At the Bongo Club, Edinburgh, 2012

There is Danger in the Air and ***And Now for Some Music***, has been to record and replay at varying speeds various control signals (another kind of resampling operation). This operation opens up the possibility (albeit not the guarantee, in practice) of having similar temporal articulations emerge at different timescales, following Vaggione (1996, 36).

I developed this bearing in mind another pragmatic maxim of John Bowers, which is to find 'crude but generally useable relationships' (Bowers, 2003, 67). To this end, the code is considerably less sophisticated and correct than contemporary attempts to model human tempo perception (Sethares, 2007). I downsample[3] some control signal considerably (by a factor of hundreds or even thousands) and then look for peaks in autocorrelation taken over relatively long timespans (seconds, or tens of seconds). The results do not provide anything like a stable pulse, but they do provide the basis for pulse tracks that are interestingly and *musically* related to their input. Running different instances of this patch at different downsampling rates allows me to derive a number of different, variable pulse tracks at different time scales that are interestingly related.

In ***Exchange. Value***, the piece is run inside the Ableton Live sequencer. As such, there is already a master clock present, so the task instead becomes one of dealing with this creatively. The clock is not controlled by audio in this case, but by interpreting MIDI note and control events as temporally significant. The goal here is twofold. First is to impose a link between the pace of physical activity and the pace of the music which can otherwise be dislocated when using a sequencer. Second is to provide an alternative to the unsatisfactory pair of synchronisation choices on offer by default: either synchronise to a master clock, or not at all. This way, each player is at a different tempo, but (in principle) if their physical playing correlates in time, so should the sound. As such, the degree of synchronisation is opened up as a territory for play. At the same time, audio onsets are also tracked (in a rough manner) and compared in density to MIDI onsets; the relative quantities of each then control the rate of update of other aspects of the patch.

The second broad mechanism—evident in all the pieces—inhibits the rate at which aspects of the patches update. This tactic owes a great deal to my eventual realisation that in Agostino Di Scipio's *Audible Ecosystemics* systems (see Section 1.1.1, 32) a principle mechanism for the forming of time lies in

[3]That is, reduce the sampling rate. In this case I take the simplest possible approach, which is simply to discard 1 in every n samples, with no pre-filtering or interpolation.

various sample-and-hold processes. This means that, rather than updating continuously—which can give rise to a dynamic but, nevertheless, undifferentiated sludge—certain aspects of the system will only shift state more slowly (and not necessarily uniformly), and possibly abruptly. Given the adaptive, coupled nature of these pieces, the result is that the system can cover a *wider* range of possible behaviours in a more musical manner as some of its adaptive behaviour is made to lag behind unfolding events, giving rise to unforeseen responses as it 'fails' to adapt quickly.

Variations on this theme can be seen throughout all the portfolio pieces. In some cases I use a uniformly slowed down rate of response by large-scale downsampling of control signals, as with otg.wobblypulse. On other occasions, I opt for non-uniform rates of change (where these rates can themselves be adaptive, by triggering updates based on other signals). For instance, in ***Spectral Dweller***, the sensitivity of the system to incoming audio is updated slowly (every few seconds), which in turn changes the way the rest of the system responds to the players.

4.5 Loudspeakers

The systems formed by loudspeakers and rooms (or some alternative method of converting electrical to acoustic energy) are of crucial significance to the ecologies that make up our instruments as electronic performers. Despite this, they are also the elements that are liable to most significant change between rehearsal and performance. The types and affordances of loudspeaker can vary markedly between different types of gig. Furthermore it is the element over which we have the most variable influence from gig to gig concerning decisions about type, quantity and placement.

It is surprising, then, that there is not a greater amount of discussion concerning loudspeakers, their significance, design or placement in the live electronic musicking literature. Simon Emmerson (2007) devotes a chapter to the history of the loudspeaker, emerging technologies, common problems and approaches. Jos Mulder (2010) makes a contribution considering loudspeakers as a substantive element of what we might consider an instrument. Dexter Morrill (1981) and Bruce Pennycook (1997) detail and make practical suggestions concerning the use of loudspeakers alongside acoustic instrumentalists, and Stockhausen and Kohl (1996) offer a range of highly practical advice on speaker placement for electronic music in general. There has also not been a

great deal of work that considers intervening seriously on the design of loudspeakers for creative ends, besides the work on hemispherical speakers first developed at Princeton, detailed by Smallwood et al. (2009).

One immediate thing to note is that reliance on sophisticated spatialisation is incompatible with having an approach that can cope with both university concert halls scattered with high-end monitors, and basement clubs with mono PAs designed for vocal reinforcement. The approach I have taken with the portfolio pieces is to detail, but not insist upon preferred configurations, should local conditions be amenable. Both ***There is Danger in the Air*** and ***And Now For Some Music*** make internal use of first-order ambisonics, so are in principle scaleable to arbitrary numbers of speakers. That notwithstanding, I have never felt tempted to make much use of sound behind audiences, if only on the pragmatic basis that it can be very hard for me to hear it.

In ***CardboardCutout***, I suggest a local speaker near the performer, and one or two spread pairs upstage of the performer, to deal with less local contributions by the machine. The use of separate front and back sets on stage, I have found, provides a very satisfying enhancement of depth—what Denis Smalley (2007) terms 'perspectival space'—at the (sometimes welcome) expense of precise localisation[4].

In ***Exchange. Value*** I propose local speakers for each performer, or distributing three pairs across three local speakers[5], which is more fiddly, but gives more scope for playful ambiguity. Again, the use of downstage pairs is encouraged if possible. The idea in ***Spectral Dweller*** is for the co-action of the two players to fuse into a single stream; the preferred configuration here is for a very narrow pair only slightly wider than and upstage of the players with additional decorrelation on the image, so as to present a wider bloom around the performers (Kendall, 1995; Zotter and Frank, 2011; Vickers, 2009). Again, upstage speakers for 'field' contributions from the machine are welcome.

The approach I have taken to using with 'local' loudspeakers has developed out of playing as part of larger ensembles, particularly alongside acoustic instrumentalists. The *de facto* type of speaker for electronics in many settings tends to be a studio monitor of some sort. These have many pleasing features,

[4]Also, I have found this approach, as a sort of very lightweight diffusion, effective when engineering for ensembles of instruments with electronics, live or fixed.

[5]Such that the players on the left and right use their immediately local speakers as their respective left and right, and the centre speaker as their respective right and left. The central player has to 'fake' a stereo spread by arranging matters so that their far left (right) comes about as the half-pan point between the central and left (right) speakers.

particularly in their ability to deal with very transient signals, but have been designed in order to have the most *uninteresting* interactions with the space as possible. This makes sense for studio monitoring, but is problematic alongside instruments, many of which are surprisingly loud. I have tended to find that having a single speaker at a comparable level means having to make sure that people are safely out of the line of fire of the very directional high frequencies, and that some people hear too much of me whilst others can't make out very much, depending on how off-axis they are. After some experimenting with firing angled speakers off walls, which gave me a more diffuse sound, but little detail, I have found a degree of success using two loudspeakers facing in opposite directions, one with its polarity flipped, as a sort of improvised dipole. This provides a certain amount of scattering, and allows enough power without firing it all in one direction.

Among the approaches least preferable, but most common is the 'standard' front of house pair, plus foldback monitoring on stage. The amount of dislocation that can result from this arrangement is significant, as the foldback has to be balanced against the backwash of low frequency sound from the front of house, and electronics require quite a significant degree of foldback compared to acoustic instruments, owing to the absence of any other feedback. Nonetheless, this is the option most frequently on offer, either because that is what the venue offers, or because it has been arrived at as a necessary compromise on a shared bill one might organise oneself.

This highlights, in fact, the way performance situations are almost always deeply collaborative. The collaboration with sound engineers, in particular, is of crucial importance; the player may only have an approximate idea of what is happening sonically to the audience, particularly if she is relying on foldback. The sound engineer confronted with a highly unstable and sometimes quite peculiar array of sounds needs to be able to decide whether it's *supposed* to sound like that or whether they should do something. In order for things to proceed with a minimum of stress, it takes a good deal of both sympathy and trust from all concerned, particularly if the engineer is more au fait with the demands of, say, rock bands; musicians need to be able to communicate somehow their expectations of the gestalt if the engineer is to have any hope of arriving at a satisfactory balance.

4.6 Sites and interpretative Games

The disjunctures that arise when re-situating performance practices into different venues are not just technological, then, but are enmeshed in a wider network of social and material connections, priorities and ideas of what music ought to be. Different ways of musicking entail different relationships with audiences, co-players, engineers, promoters etc. as part of the interpretative game (see Section 2.3, p. 83), which are in turn enacted through and supported by various material and immaterial technological webs (such as sound reproduction equipment, chairs and money).

The nature of the different social/technical spaces in which electronic musicking is liable to happen is, again, only seldom raised in the formal literature. Simon Emmerson (2001) takes a broad view of the matter whilst imagining an inclusive type of venue for a variety of practices, following Illich's idea of *conviviality* (to which we return in Chapter 5). A wonderful article by Warren Burt (2001) takes a more empirical approach by surveying the 43 distinct sites he performed at over the course of a year, highlighting their musical differences as more substantively social than stylistic. Nevertheless, a governing assumption in much of the available discourse seems to be that unless otherwise mentioned when we speak of performance we speak of proscenium arches, and silent, seated, still audiences, who are thus presumably attentive.

As a marker of unreasonable privilege I have been able to incubate much of the practice that happened around the portfolio pieces in the safe, institutionally supported setting of 'experimental music', where the social code broadly follows the Western concert model of shutting up and listening, and restricting the imbibing of substances to either side of a performance. Additionally, I have access to a whole range of material and social resources—equipment, peer support, articles and books, spaces—that would otherwise be considerably harder to come by. This brings with it a range of particular affordances—the luxury of being able to try out lavish combinations of loudspeakers, for instance, as well as having a context in which to share work that is not altogether developed.

However, in common with all other musicians I know, this did not form my only performance context by any means[6]—I became heavily involved in (part of) Edinburgh's underground hip-hop scene, worked as a community musician, and did gigs with a folk pop band, among other things. These in

[6] As Simon Frith (1996) points out, that mobility between musical spaces has historically been the rule is one of the factors that makes high/low art distinctions so suspect.

turn have afforded a different range of ways of knowing, in terms of stagecraft, professional conduct, and stark realisations about the profundity of musical co-presence, to give some examples. A lasting frustration, or perhaps impatience, has been in how these different 'zones' of practice can be made to tessellate into something that feels like they are part of a more contiguous musical identity, which in turn lays bedding for a channel of future work.

A project I have repeatedly started but that is still unrealised is of integrating elements of the autonomous-machinic practice presented here with the activities of my improvising hip-hop group, *Sileni*. The aim is to develop a more satisfying performance ecology than I can fashion with my default set-up of Ableton Live, for example by being able to delegate certain streams of musical action to the computer, by somehow streamlining the selection of new samples to work with, and by allowing the course of computerised decisions to be affected by the MC's vocal contribution. However, to date, each time I have approached this project, I have slid off. After some reflection it occurred to me that it is partly to do with a set of much stricter, but nonetheless nuanced, aesthetic expectations about the enaction of musical time in the milieu in which *Sileni* operates, and what these expectations imply for the kinds of loose, exploratory coupling between machine and me that I have preferred in this research. The challenges involved may appear solely technical, such as devising creative ways of interacting with the gridded nature of sequencer-time (as in ***Exchange. Value***) and of grabbing samples.

However, my gradual realisation has been that there is a considerably more complex set of constraints at work in terms of how the intermingling of musical priorities at work are reflected in the affordances of whatever assemblage results. These musical priorities are informed by the idiomatic commitments we have adopted of improvising within an interpretative game of hip-hop, which is what introduces the greater complexity of constraints. For instance, listening attention in this interpretative game features particular focus on micro-temporal aspects of the groove, and an important marker of competent play is in how the *messiness* of improvised conduct can be made to interact with the groove—by maintaining, warping, reinforcing, dislocating or simply confusing it. By extension, this makes the *performance of timeliness* a critical element, by which I mean that there is congruence between the timescales at which I act and at which critical appraisal is conducted. Many aspects of what I am currently able to do in Ableton Live interfere with such congruence, and this interference arises not only from the software's, doubtless

well-intentioned, attempts to insulate the user from the risks of playing out of time, but also from the fact that I collude in this by having paid insufficient attention to my ability to play good time.

This in turn has made me wonder if a shortcoming of the avowedly experimental music scene could be that it is under-critical in certain respects, the enaction of musical *timeliness* being one such, on the basis that the critical priorities of the interpretative game at hand simply lie elsewhere. The corollary of this would seem to be that, in order for the community of practice around experimental music to avoid the atrophy of particular, important types of musicality (and by extension the sorts of social co-being that they bring forth) either the interpretative game needs to widen its priorities and/or we should be wetting our feet in a wider range of ponds. Fortunately, the latter seems to be general rule in any case. The value in a future, integrative strain of work, as I see it, would be in contributing further practical and discursive methods for normalising the folding-in of wider musical experience and practice to experimental musicking, whilst retaining the experimental music concert as—at its best—a supportive space where failure is most definitely an option.

4.7 Summary

Performing involves encountering a range of contingencies quite distinct from those explored in the preceding chapter. Part of this, I have suggested, arises from the particular durational qualities of performance, both as a locus of practice towards which activities are orientated, and as a peculiar and intense kind of experienced duration. As such, performances of early incarnations of the portfolio pieces have folded back onto their subsequent in ways similar but distinguishable from those described in Chapter 3. I have taken a similar approach in this chapter, in trying to be both critical and frank, and to emphasise the mutability of my musicking in response to practical circumstances. There have been four areas of focus. First, how the portfolio pieces reflect my on-going engagement with the problematics of bodily involvement in live electronic music *vis-a-vis* the disposition of resources and my physical orientation to them. Second, the temporal behaviour of the pieces, with particular attention paid to how the tendency to continuous streams can be interrupted, and how experiences of performing inflected the approach to macro-temporal aspects of these systems. Third, I considered briefly the relationship with loud-

speakers, as a crucial but sometimes uncontrollable aspect of the performance ecology. Finally, I acknowledge particular performance sites as particular social spaces where the interpretative games being played have consequences on performative affordances.

Each of these topics presents fertile ground for further research. Most personally pressing is to develop more deeply my thinking and acting on the interrelating of musical time and social space as it pertains to the various tendrils of my practice. The technological mechanisms I have derived for handling longer time scales in the portfolio pieces are promising, but not yet developed enough to feel intuitive in putting them together. This calls, I think, not only for more technical work, but also further phenomenological work aimed at helping develop the discourse around time and improvised and electronic musicking. Likewise, the consideration of social space and how practices traverse different kinds of interpretative game will benefit from such experientially grounded reflection. In the closing section of the following chapter, I argue that such traversal is common among practitioners but neglected in our formal communication and that remedying this could be of significant benefit to our intra- and inter-disciplinary discourses.

With this in mind, then, the following chapter considers publishing or otherwise releasing musical research as an act of *letting go*, complementary to the grabbing and holding on already discussed. In order to discuss the various documentary strategies I have adopted, I first present a framework and context for evaluating these strategies, in terms of recent discourses around practice-led research and the interdisciplinary status of live electronic music. In the final part of the chapter I approach the matter of our musical relations with a wider public obliquely, by treating it as an issue of how we communicate within the discipline and the implications this has for the breadth, location and accessibility of our musical conduct.

Chapter 5

Letting Go

I have characterised various interweaving aspects of the way in which the portfolio work has developed in terms of *grabbing* and *holding on* in order to illustrate ways in which my relationships with tools and the process of design, and my experiences of performing have had constitutive effects on the pieces. A further, and critical part of the research endeavour, of course, lies in the material traces left by this work: its documentation and contextualisation into the world. Producing these traces constitutes a degree of *letting go* of the work, insofar as they are distinguishable from designing and performing by my physical absence. Lines are drawn, however contingently, around what has taken place, and direct in-the-moment co-involvement in interpreting is abdicated.

But, of course, the choices over what forms these traces take are not neutral with respect to the types of information they afford, and the sorts of relationship they encourage. Who are these documentary traces aimed at? In what ways do I imagine them to be useful to their audience? What insights on the possibility of future improvements are yielded by critical reflection on these questions? In order to tackle these questions, I consider first the work I have presented as a piece of practice-led research, and situate the types of knowledge claim I make alongside existing discourse on the subject. That is, I propose the worth of the approach as academic research as such, and so address the imagined community of academia. Practice-led research into live electronic music involves a number of much more concrete scholarly relationships though, and these traverse a range of disciplinary boundaries. It is these relationships I go on to consider in the context of recent critical work on interdisciplinarity. How do we address colleagues in allied endeavours? What

are the distinctive focal points of practice-led research into live electronics as a sub-discipline of music?

Finally, I consider the situation of live electronics as a simultaneous research community and musical sub-culture. I pursue this, speculatively, through the lens of *conviviality* (Illich, [1973] 2001), as a way of considering the position of the discipline as a coherent discursive and musical body. I suggest that problematic issues around the quality of our communication and the public standing of our musical activities may be related, and develop some areas for future investigation that seek to address these problems by integrating practices into our formal discourse that I take to be already, informally, present.

5.1 Practice-Led Research

Increasing attention has been given to the idea of practice-led research in recent years as scholars consider the role and nature of practice in research and, crucially, what is needed in order for practice-led approaches to conform to research norms (Smith and Dean, 2009; Barrett and Bolt, 2007). Whilst this is indicative of an academic environment that is becoming hospitable to different forms of knowledge development and communication, practice-led discourse also takes place in an environment in which researchers are increasingly subject to competitive structures and hierarchical management, which has brought with it an attendant instrumentalisation of research and of universities themselves (Lorenz, 2012). As such, there is a degree of urgency for practice-led researchers, amid dwindling funding opportunities and increasingly casualised labour conditions, to be able to account for the value of their activities as part of the endeavour of academic research.

This urgency notwithstanding, surprisingly little discussion has taken place around the particularities of practice-led research for live electronics or electroacoustic music research more generally. There have been various discussions of the ways in which these research areas are interdisciplinary, as we shall see in the following section, but—as yet—scant attention has been devoted to what might distinguish live electronic music research from, say, related projects in interface design, such as the activities that take place under the banner of New Interfaces for Musical Expression (NIME).

I shall approach this with respect to the research I have undertaken in relation to three specific areas: *knowledge claims*, *research outcomes*, and *evaluation*.

5.1.1 Knowledge Claims

In experimental scientific research, a core principle of how knowledge claims are rendered legitimate lies in the reproducibility of the work. Scrupulous attention is paid to the experimental environment and to detailing the steps taken. Variable factors are controlled to the degree possible, and sources of error accounted for in order to assess the degree of certainty in results. Replication of results by independent groups, following the documented procedure is of great importance to validation, and so it is a problematic matter if they can not be reproduced.

For the creative arts, these conditions simply do not obtain for much of what takes place. There is no sense, for instance, in which a public performance could be likened to laboratory conditions, given the numerous sources of quite dramatic variation. The visual arts researcher, Barbara Bolt (2008) suggests that it is in this very contrast that the possibility to make a positive case for the knowledge claims of practice-led research lies. Bolt argues that the repeated act of *handling* materials, since it can not constitute a repetition as such, becomes 'the "stuff" of research' (6) that 'allows us to recognise the conventions (context of theory, context of practice) and map the ruptures that shift practice' (7). She casts this perspective as *performative*, in the sense of Austin and Butler we encountered in the introductory chapter, insofar as practice produces effects in the world that are formative of the self-hood of the practitioner, and of the context of conventions in which she operates.

I read Bolt's account as being largely in agreement with elements of the perspective I developed in Chapter 2, although pitched at a more general level. Prolonged, practical engagement can produce productive insights into the nature of tacit knowledges and cultural assumptions which form the context in which we dwell. Likewise, I have proposed that live electronic musical practice is diffused across diverse networks of technologies, other materials and social sites, as well involving a range of different ways of knowing the world, and that an understanding of the dynamics of the resulting relationships can be effectively and distinctively grasped through reflective practice.

5.1.2 Outcomes

How, then, do these knowledge claims crystallise into a form that can communicate to an audience? Bolt takes the view that rather than treating the outcome of practice-led research as an artwork with some supporting contextualisation,

> The task of the exegesis is not just to explain or contextualise practice, but rather is to produce movement in thought itself. It is these "shocks to thought" that constitute the work of art and, in conjunction with the artworks, it forms the material of creative arts research. Such movement cannot be gained through contemplative knowledge alone, but takes the form of concrete understandings which arise in our dealings with ideas, tools and materials of practice. It is not the job of the artwork to articulate these, no matter how articulate that artwork may be. Rather, the exegesis provides a vehicle through which the work of art can find a discursive form. (Bolt, 2007, 33)

This model, whereby the textual and, in my case, musical components are both intended to form substantive elements is taken somewhat further by Wilkie et al. (2010), who propose the idea of 'creative assemblages' to denote the ways in 'practice-led research is heterogeneously composed' (99). The notion takes account of the way in which practice-led research can take place across a variety of disciplinary boundaries and exhibit a tendency towards continual development, rather than stable outputs. Furthermore, they suggest a simple analytical model, expressed in terms of how *loose / compact* and *open / closed* assemblages are.

The outcomes of the research I have undertaken are, in these terms, loose and open insofar as they take multiple forms, spread across a number of contexts, in which a number of actors and agents appear (loose), and in which I have tried to make all parts available (open). My musical approach is not characterised by a strong concept of the work, but is orientated to a practice where improvisation plays a central role in performance. As such, the portfolio pieces serve both as particular outcomes—in that they support particular ways of improvising—and as traces of particular strands of practice that remain available for further revision, recombination or recycling, either by me or any other interested party.

In this sense, there are no *a priori* grounds for according greater or lesser status to the submitted recordings or their associated software and documentation *as research outcomes*, as they form co-dependent aspects of the same overall assemblage. Likewise, these strands of practice have not emerged independently of the text that you are reading, which itself has adopted a

number of different tactics that I intend, as Bolt suggests, not just to explain or contextualise, but to afford 'shocks to thought' in the form of theoretical contributions.

5.1.3 Evaluation

By what criteria should such a creative assemblage be evaluated? Where, in other words, is the value to be found, and by whom? This is a complex and vexatious issue on a number of fronts. First, as Tomas Hellström observes, research in the creative arts may differ from scientific enquiry insofar as 'tacit understanding and indeterminacy of outcomes are accepted and expected' (Hellström, 2010, 308), so that the formulation of projects in terms of clearly testable research questions can be problematic. In Bolt's terms, above, there is an assumed degree of emergence that occurs through the process of handling. Starting proposals, then, may well be expressed more commonly in terms of a general area of examination, without a hugely detailed idea of how the resulting outcomes may be formed and interlinked. For instance, in the case of this research, the starting motivations were couched principally in terms of some personal goals for the development of my practice, and a less certain impression of what form a wider contribution might take.

Accepting a degree of indeterminacy suggests that robust evaluation is not going to be simply achieved by attempting a mapping between originating impulses and outcomes, given the degree to which this could gloss over potentially valuable features that have emerged in the process of research. As well as considering the relationship of starting proposal to ending outcomes then, there needs to be a way of considering the value of the outcomes in a wider context, as with any other research. Hellström goes on to provide a simple mapping of the terrain of this problem in terms of public versus private goods, and intrinsic versus extrinsic value, with which we can start to unpack this issue for live electronic music.

By intrinsic and extrinsic value, Hellström distinguishes between evaluation strategies for art that attend to ostensibly internal properties of the work (beauty, unity), and those that establish value in relation to some 'external' reference, which may or may not be taken to act as a *proxy* indicator for intrinsic values. This distinction is, of course, by no means unprecedented in the discussion of music. Indeed, it features as a central theme of a great deal of recent scholarship, much of which is concerned with rendering

an internal-external binary problematic (Waters, 2007; Born, 2010b; Shusterman, 2002; Davis, 2011; DeNora, 2000; Emmerson, 2007; Clarke, 2005). Such is the case with the arguments I have put forward in this dissertation. In particular, I have taken much from Richard Shusterman's idea of *interpretative games* and the notion of *performance ecosystems*, from Simon Waters, in order to present a stance that recognises that the specific meanings and value of music arise in particular social and historical settings, and that a process of *sense-making* (Varela, Thompson and Rosch, 1991; De Jaegher and Di Paolo, 2007) can account for the significance of 'intrinsic' qualities in these situated, negotiated settings. Consequently, Hellström's distinction between public and private becomes crucial for the purposes of evaluation, so we can highlight the interpretive communities that the work is aimed at.

Before moving on to this, however, it is worthwhile to note the particular utility of the notion of *proxies* in Hellström's account, because it provides an elegant shorthand for approaching the sometimes uncomfortable relationship between speculative musical practices and institutional desires for unambiguous indicators of value. A proxy here is taken to be some mechanism that stands as a marker of quality, such as audience numbers, turnover, peer review or citation counts. Hellström argues that

> if, as is now common, such external processes are taken as proxies for epistemic quality in a project, its legitimacy rests on an assumption that others, peers, have deemed the project to be of high academic quality and awarded resources for that reason... The inference of quality from previous judgements and allocations by others assumes a consensus about what the goals and outcomes of a research process ought to be. While such consensus is norm rather than exception in paradigmatic science, for aesthetic objects and processes it may be, in principle, impossible (Hellström, 2010, 310).

Whilst there may be consensuses apparent on evaluative proxies for musical objects, this is a more problematic notion for music-as-practice. The argument that practice is good in itself is seductive, but also idealistic and fails to confront the pragmatic necessity of making ourselves understood to those agencies who determine research priorities and funding. This tension is an example of what Tim Ingold identifies as a defining feature of 'the dynamic of industrial society' (Ingold, 2000, 333), characterised in terms of the various mismatches between a 'dwelling perspective' and a 'commodity perspective'. A commodity perspective is taken to form the 'institutional and ideological framework' (338) of Western modernity that, in the process of making classifications, produces sets of oppositions—such as work versus leisure, or, for

our purposes, successful versus unsuccessful art. These oppositions can run against the grain of a lived experience of more porous and unstable distinctions, denoted by Ingold as the dwelling perspective. Ingold's argument is that life in modernity can not be understood through the antagonism of these perspectives, but by their dialectical relationship. This model has a good deal to offer a theorisation of the place of arts research, I believe, as it offers a mechanism for resisting the impulse to idealise the notion of music-as-practice as somehow transcending the conditions of industrial capitalism, and instead for integrating critical reflection on our interactions with institutional frameworks into research processes and discourse.

For the purposes of our discussion of evaluation, the notion of commodity and dwelling perspectives helps to underscore the critical importance of considering what Hellström calls 'an extended stakeholder set' (Hellström, 2010, 315) as a distributed evaluative network for our assemblages of outcomes. If the set of 'consumers' assumed by the musical commodity perspective is inadequate to satisfactorily positioning this research, then it is nonetheless productive to attempt to explain the work in commodity terms, aimed at different, possibly quite dispersed stakeholders as part of capturing some character of how the dynamic between dwelling and commodifying unfolds in this particular case. In this sense, Hellström's second distinction, between research as private and public goods, is apposite—coming as it does from economics.

In Hellström's argument, private research addresses only the personal goals of the researcher and the latter positions outcomes as some sort of public good. This distinction is certainly recognisable from discussions one sometimes has about the role and value of practice-led music research. Compositions may be argued to form a cultural contribution by dint of their existence, whilst satisfying a private need on the part of the composer to work at their art. But this is inadequate to the task of explaining the value of more dispersed or ephemeral outcomes, or of accounting for how such a cultural contribution is made manifest. Usefully, Hellström extends the binary of private and public goods with the notion of a *club* good, where 'part of their value is only appropriated by a limited group of practitioners' (309). I take all forms of musical production to constitute club goods of this sort, recalling Small and Frith's insistence that all forms of musical participation be taken seriously as practice (Small, 1998; Frith, 1996) and Shusterman's notion of meaning and value arising in particular interpretative communities. No music enjoys completely universal appeal, nor completely uniform interpretative games, after all.

Applied to the idea of the outcome of this work forming a creative assemblage, different aspects of the assemblage will afford having their value appropriated by different interpretative communities (clubs). Some of these communities will be fellow researchers in allied disciplines or practitioner-researcher colleagues, some will be further flung. An important aspect of the correspondence with other researchers comes about due to the interdisciplinarity of live electronics practice, and it is to this I turn my attention next, in order to present an account of how such interdisciplinary valences may be characterised. This provides a basis on which to evaluate the methods I have used to present and develop this research with respect to its academic affordances. The question of how practice-led musical research in general, and live electronics in particular, interfaces with the wider world I take to be a good deal more complicated. I finish the chapter with an argument that relates our success at doing so as a discipline to the standards and protocols *within* the discipline itself, and suggests some possible approaches to investigate making our extra- and intra-disciplinary communication orientated towards *conviviality*.

5.2 Live Electronic Musicking as an Interdiscipline

Interdisciplinarity is a contemporary commonplace in academic discourse and—as both Simon Emmerson (2007) and Leigh Landy (2007) point out—it has always been an inherent aspect of the study of music in general, and electroacoustic music in particular. What, in practical terms, does this mean though? The idea of interdisciplinarity puts into relief a tension in the modern academy. On the one hand, a collegial ideal of cooperative work and relational acceptance of the differing perspectives afforded by diverse methodologies is promoted by increasing awareness of the nature of disciplinary boundaries as social constructions rather than epistemological givens (Latour, 1993). On the other hand, interdisciplinarity is promoted by government in terms of rendering research more accountable to the public and of achieving tighter integration with business, in the name of greater innovation (Barry, Born and Weszkalnys, 2008).

This governmental focus arises in the context of the New Public Management discourse that has set about remodelling universities and other public institutions in the image of the late capitalist enterprise in recent decades, and warrants being approached warily. Lorenz (2012) argues that, among many

other problems, this discourse is 'parasitical' upon language when it mobilises terms like accountability, insofar as their institutional enactment has less to do with the sensible sounding rationale—who would not want research to be accountable or innovative?—and more to do with reproducing the authority of management over an increasingly cowed and casualised workforce. This leaves a perilous situation for the study of music and the arts in general, and practice-led research especially, in the face of pressure to frame outcomes in increasingly positivist terms whilst remaining 'competitive' in the search for dwindling opportunities, resources and funds.

The idea of interdisciplinarity, then, ends up standing for both the idea of collegial collaboration (however difficult to manage in practice) and for a more individuated model where it is incumbent upon researchers to 'speak' more than one discipline. As a worst case, this could result in a 'jack of all trades, master of none' situation, wherein interdisciplinary research ends up being a poorly stitched quilt of superficially applied borrowings—breadth but no depth. A way of averting this is possible, I think, if one is sensitive to the idea that particular disciplines, however constructed, orientate themselves around particular practices that afford particular ways of knowing. To start to combine these practices is unlikely to leave either the practices or the afforded ways of knowing unaffected, if pursued in a principled manner. To make a signal processing metaphor, these are more like convolutive mixtures than additive mixtures: the components interact with each other, highlighting certain aspects, possibly suppressing others.

For instance, when Landy (2007, 185) describes a 'fundamental knowledge of acoustics' as a '*sine qua non*' of electroacoustic practice, it should be reasonably obvious that this acoustic knowing is not isomorphic with an acoustician's. Electroacoustic musicians rarely speak (or presumably think) in terms of wave equations, acoustic impedances or other elements that an acoustician may consider fundamental to acoustics as a discipline, even if some musicians understand this way of approaching the topic perfectly well. Rather, the knowing of acoustics that goes on will be a combination of using certain simplifying models from acoustics when designing sound—for instance, the temporal unfolding of reverberation in terms of early reflections and late, diffuse behaviour—and a situated, possibly tacit, knowing embedded in a history of practices. For instance, a history of listening to chamber instruments in enclosed spaces will contribute to a way of knowing acoustics in a particular way, and a history of listening to loudspeakers in enclosed spaces may well be

productive of a distinct (if similar) knowing. These knowings will *interact*: an experienced listening-knower might well develop skill at intuiting reasonable positions for loudspeakers so as to preserve clarity (if that is the aim) without recourse to measurement, and she might get to that skilled position via any number of practice-histories.

Barry, Born and Weszkalnys (2008) provide a way of formalising and extending these observations by highlighting three different *modes* and three different *logics* of interdisciplinarity[1]. An *integrative-synthesis* mode occurs when an additive approach is taken combining different disciplinary approaches; a *subordination-service* mode, where one set of disciplinary practices is mobilised in service of another; and an *agonistic-antagonistic* mode that

> springs from a self-conscious dialogue with, criticism of or opposition to the intellectual, ethical or political limits of established disciplines or the status of academic research in general (29)

Alongside these modes, three different logics tend to account for different underlying rationales of interdisciplinary practice. The first two, logics of *accountability* and *innovation*, denote ways in which interdisciplinary collaborations may be positioned in terms of issues like public communication and legitimation, or as ways of provoking novel movement within a discipline or enterprise. The third logic they describe as a *logic of ontology*, and characterise this in terms of interdisciplinary collaborations that seek to 're-conceive both the object(s) of research and the relations between research subjects and objects' (25). These modes and logics can overlap and interact, and can all be seen at work in the diverse interdisciplinary relationships of live electronic and electroacoustic musicking.

5.2.1 Interdisciplinary Discourses of Electroacoustics

The general disciplinary area in which live electronics takes place suffers from a degree of poor definition, which can be seen in a glut of competing and overlapping labels, such as electroacoustic music, computer music, or experimental music. Landy (2007) introduces the term *sound-based* music in an attempt to make a clearer, and less technologically determined delineation of the field, which is welcome in that it leaves room to acknowledge the similarities between branches of practice without falling into a chauvinistic attitude

[1] Barry, Born and Weszkalnys (2008) stress that these are not meant to be exhaustive or exclusive. They were arrived at empirically, through reviewing diverse interdisciplinary projects, so are available for extension or revision.

about the means employed. However, I have a concern that it rests on a distinction—as oppositional to *note-based* music—that may well be less evident to people not already familiar with the discursive history of the field, and that certain musical practices remain problematic[2].

Allegiance to one or another of these labels seems to have some bearing on how disciplinary components are positioned. Computer music, for instance, seems to describe itself in technical terms. Curtis Roads, in his canonical textbook, aligns the field with 'composition, acoustics, psychoacoustics, physics, signal processing, synthesis, composition [again], performance, computer science, and electrical engineering' (Roads, 1996, xiv). Similarly, F. Richard Moore places computer music at the centre of a paradigmatic disciplinary web bordered by music, computer science, engineering, physics and psychology. These in turn combine to produce specific sub-disciplines that concern computer music, such as artificial intelligence, music psychology or digital signal processing. Moore frames his discussion in terms of being able to deal with 'objective and subjective properties of sound' (Moore, 1990, 24). This seems to indicate an interdisciplinary mode of *integrative-synthesis*, but also a model where the practical business of composing and performing is informed only from a range of quantitative practices with little attention apparently paid to these practices as being socially situated.

Acoustic Communication	Media Theory
Acoustics	Music Cognition
Audiovisual Theory	Music Education
Cognitive Science	Music Perception
Complex Systems	Music Psychology
Computing	Philosophy
Critical Theory	Probability Theory
Cultural Theory	Psychoacoustics
Cybernetics	Semiotics
Interactivity	Signal Processing
Interdisciplinary Studies	Virtual Reality
Linguistics	

Table 5.1: Constituent subjects of Electroacoustic Studies from Landy (2007, 184).

Meanwhile, Simon Emmerson (2007, xiii), concerns himself with electroacoustic music and casts a wider net that takes in anthropology and social

[2]Practices like hip-hop, or certain minimalist works, for instance.

science, and declares *musical experience* to be a core concern. Landy (2007) suggests a list of 23 particular subjects, in addition to musicology, pertinent to sound-based music studies, given in Table 5.1, which gives a broad account of the possible scope of disciplines involved. Despite seeming somewhat incomplete and scattered, the inclusion of critical theorising into the disciplinary mix suggests greater potential for an agonistic-antagonistic mode of interdisciplinarity, whereby reflection on engagements with the technics of our practice can orientate themselves critically towards the, possibly unstated, ontological assumptions of designs or theories (Feenberg, 1999, see also Section 2.2.1, p. 71).

5.2.2 Live Electronics and its Neighbours

I have argued that a mapping of the interdisciplinary neighbourhood of a piece of practice-led research is necessary for evaluation purposes so that the academic audiences can be identified. With respect to live electronics, this audience will be composed, in the first instance, of fellow electroacoustic musicians, whether live or studio-based (not that their respective discourses are identical). I want to pay particular attention, however, to the relationship of live electronics to the other major sub-disciplines of music, and to our immediate colleagues in closely related technical research endeavours, particularly the work that occurs under the banner of New Interfaces for Musical Expression (NIME). What is the role of practice-led research in contributing to these discourses, and how do they, in turn, constitute live electronics as a field?

In a recent article Georgina Born presents a highly detailed framework that considers the components of a 'relational musicology', with the aim of showing how the study of music is inherently interdisciplinary, and so requires the differently focused contributions of the various musical sub-disciplines and their respective orientations to wider endeavours, such as anthropology and history (Born, 2010a). It should perhaps be taken as an alarming indicator of the marginality of practice-led musical research that it does not appear in this paper as a possible contributor. Nevertheless, Born's framework is impressive in scope, and helpful in considering how it is that practice-led research can contribute to the larger musical discipline. Born proposes four broad topics that delineate the study of music: sociality, temporality, ontology and technology. Sociality has four distinct levels, ranging from the microsocial relations of musicking, through imagined communities of practice, to broader social scopes that account for music's part in the social differentiation of race, class

and gender, up to how music is involved with the broadest social formations at the level of the political and economic structures. Interdisciplinary approaches are needed to grasp this spread because

> the four orders of social mediation are irreducible to one another; they are articulated in non-linear and contingent ways through conditioning, affordance or causality. While they are invariably treated separately in discussions of music and the social, all four orders enter into musical experience. The first two orders amount to socialities, social relations and imaginaries that are assembled specifically by musical practice. The last two orders, in contrast, amount to wider social conditions that themselves afford certain kinds of musical practice—although these conditions also permeate music's socialities and imagined communities, just as music inflects these wider conditions (Born, 2010a, 232–233).

Temporality is treated by Born with a similar four-level approach. The first temporal level corresponds to the inner time of music. The second to the ways in which musical works or acts can refer back to antecedent music, or seem to anticipate future musical works or acts. The third accounts for the formation and changing dynamics of genres. Finally, the fourth takes in the broad sweep of 'epochal categories of cultural-historical consciousness evident in notions of "tradition", "classicism", "modernism", "innovation", "avant-garde" and so on' (p. 240).

By including ontology as a topic of musical study, Born stresses both that the endeavour of musical research 'would do well to be alert to the diversity of music ontologies in the world' (p. 241)—rather than taking the nature of the musical subject-object relationship as a given—and that researchers need to be reflexively alert to their own ontological stances, and the ways in which these can structure or guide their work. With respect to the final topic, technology, Born's focus is principally on consideration of the ramifications of recording on the production and consumption of music, particularly how this can be understood relative to different musical ontologies. This framework can form a valuable basis for considering the content of reflective practice-led research and the contribution that it could make to the wider discipline, which is why I have described it in some detail.

The levels of sociality provide a valuable basis through which to examine the social nature of our practice, and to appreciate those aspects over which we may have some agency and those that we may not notice, but should attend to. It also helps form an awareness of the scope of the questions that practice-led research is equipped to deal with, to resist the urge to try and account

for the mechanics of some higher level formation when such an explanation is beyond methodological reach.

In a similar way, Born's treatment of temporality can serve as a useful template for considering aspects of our practice and how we present it. But it also bears some extension, so that temporal focus is not just on the imagined musical object—the quanta of performances or works—but encompasses also the various forms of duration (lived time) that go in to a musical practice, not least the ways in which other durations (practising, developing, application-writing, waiting) inflect social, ontological and technological aspects.

Considering musical ontologies in both a pluralistic and self-reflexive manner is of significant practical and theoretical benefit to practice-led music research, but we also need to consider how it is that we can render such questions tractable. My experience has been that to approach ontological matters in abstract, philosophical terms can sometimes have paralysing effects on one's practical work, particularly if one becomes entangled for explanations of universal scope. In this respect, being mindful of pluralism serves, again, to usefully delimit the scope of what we can hope to engage with through practice and reflection, namely how our particular musicking enacts diverse musical ontologies across varying sites and engagements, not least with respect to the authoritative position that academic participation can bestow.

With respect to sociality, temporality and ontology, practice-led researchers are able to contribute to the wider study of music by being able to account for how it is that we *live* these topics in musicking. Superficially, this could seem to constitute a *subordination-service* mode of interdisciplinarity, where practice-led research merely feeds its neighbouring disciplines with data. However, there is also scope for a more *agonistic-antagonistic* mode whereby rigorously theorised accounts of practice can contribute to the ongoing formation of disciplinary boundaries and subject-object conceptions, by dint of practice's diachronic, nomadic and emergent nature. Equally, the findings of musicology, ethnomusicology, sociologies and anthropologies of music, popular musicology, music psychology, music education and community music should be able to engage agonistically with bases of practice-led musical research, as with Born's investigation of IRCAM (Born, 1995).

Finally, technology, and especially recording, already account for a significant portion of electroacoustic discourse. As we saw above, for some authors, the topic forms the primary interdisciplinary aspect of the field. As noted by Landy (2007, 18) and Waters (2007), technological aspects of practice receive

rather too much attention in relation to other musical or social concerns. Put another way, there is a need for our discussions of technology to integrate more fruitfully with these other topics of sociality, temporality and ontology. Whilst a preoccupation with matters technical can be explained in the light of ongoing, continuous and destabilising technological change that brings opportunities for innovation—but also the need to cope with obsolescence and incompatibility—a critical appreciation for the role it plays in our musical practices requires that we are able to develop a meta-technological discourse if we are to be able to communicate and deal with change effectively. Integrating technological with social, temporal and ontological insights could be of significant value to the electroacoustic sub-discipline. Not only could it provide a basis on which to collectively develop insights around the conditions of our practice, but also one on which we are well positioned to make substantive contributions to the wider study of music (following, for instance Armstrong, 2006; Magnusson, 2009; Di Scipio, 1998, as well as my own contribution in Chapter 2).

Born (2010a), for instance, concentrates her remarks on the formative role that recording plays in our experience and understanding of musicking, and draws attention to the need to enrich oppositional portrayals of recordings and live performance, in order to account for the different ways that this relationship manifests in practice for different musics. Practice-led electroacoustic researchers could potentially offer a great deal to such a discussion, given the centrality, and diverse manifestations of recording in our practices. Those of us that perform tend to do so in a variety of diverse situations, and could account on that basis for the different ways in which the relationship between the recorded and the live can be negotiated. Furthermore, those of us with studio practices—as composers, sound engineers, or producers—are well placed to contribute to developing a relational account of recording and performance in some depth and breadth, made all the richer by taking account of the valuable work being done in musicology, ethnomusicology, auditory culture studies, and science and technology studies. In this respect, there is again scope for productive agonistic exchange, as diverse methodologies afford a range of complementary perspectives.

The topic of technology also brings into consideration the relationship of practice-led electroacoustic research to its allied technical disciplines. In recent years the conferences, and attendant research activity, under the banner of NIME have grown in size, and have become an important discursive site for

researchers in live electronics, in addition to other established conferences[3]. NIME is a particularly interesting example for the extent to which its contributions feature live performance as a predominant concern, as a great many of its papers focus on technical issues of instrument design, often by presenting the technical structure of a new instrument. Less prominent are papers that devote themselves to placing these devices in social context, or considering them over an extended period of engagement. In this respect, it is worth noting that NIME began as an offshoot of a human-computer interaction (HCI) conference, and still positions itself as being principally concerned with interaction design as a sub-discipline of HCI. This, in turn, should alert us that the interdisciplinary connections, modes and logics are likely to be quite diverse across participants. From the perspective of HCI, for instance, music is a distinct and interesting domain in which to test out principles, and can cater easily for interdisciplinary logics of accountability and innovation in producing novel and potentially useful (even saleable) outcomes, whilst perhaps also providing a site in which to develop agonistic modes of interaction with neighbouring disciplines such as psychology.

Consequently, within NIME there may well be many people working on ostensibly the same things, but towards quite different, *institutionally structured*, ends. This is not intrinsically problematic, but for the asymmetry of resources that NIME's component disciplines bring to proceedings, and a resulting difference in ability to engage critically with its ontological premises. Each component of the notion of New Interfaces for Musical Expression warrants critical engagement and, indeed, such engagement would seem to fall neatly into the remit of practice-led research in live electronics. Some authors have managed to do this very effectively, such as the playful notion of infra-instruments suggested by John Bowers and Phil Archer (Bowers and Archer, 2005). Other attempts to look critically at conference themes, such as a discussion of expression by Christopher Dobrian and Daniel Koppelman underscore the need for a more thoroughgoing theorising of practice and performance, insofar as their notion of expression remains rooted in something broadcast from stage to audience, rather than as the negotiated outcome of collective, interpretative work (Dobrian and Koppelman, 2006). Live electronics has an opportunity to engage agonistically with NIME on the basis of an interdisciplinarity logic of ontology. However, in a context where our internal

[3]Such as the International Computer Music Conference, the Sound Music and Computing Conference, and the Electroacoustic Music Studies Network Conference.

discourse is already overfull of uncritical technological discussion, and where the accumulating output of NIME forms the basis of the closest available thing to specialised coverage of live electronic musicking, I worry that there is a danger that live electronics comes to define itself in terms of a specialised sub-discipline of interaction design, rather than a musical undertaking.

5.2.3 The Need for Disciplinary Coherence

I take it to be an urgent task to develop further the nature of the interdisciplinary valences of live electronics, and to devise methodological approaches geared towards documenting and reflecting upon practice in a wider, more socially situated and diachronic sense than concentrating either upon the functional aspects of our technology or the punctuating quanta of finished works or performances. First, given the precarious status of practice based research in the current outcome-driven policy environment, there is a need for advocacy for how it is, distinctively, that practice-led research can contribute to our collective sense-making. Second, as a corollary, such explanation is useful for successful communication and collaboration with colleagues in allied disciplines. For example, if, as I have argued, the ways of our practices engender different ways of knowing technology (or music), then there needs to be some basis for articulating the distinctiveness and value of this knowing to colleagues in technical, or other musical, disciplines such that we don't just talk past each other. Third, if we value the idiosyncrasy and diversity of our musical practices and languages, then a coherent and effective alternative to normative musical discourses is required in order for communication and sense-making within the local interdiscipline to be possible, within and outwith the borders of the academy. Fourth, there is an issue of pedagogical coherence; in the absence of any methodological 'pathways' for live electronics it has been my experience that students struggle with reflecting upon the local, particular materialities and phenomena of their practices, and veer between producing technologically-based descriptions, or attempting theoretical extrapolations that risk bearing little relationship to their creative work.

Born's framework of sociality, temporality, ontology and technology is a useful way of exploring the situation of live electronics and electroacoustics *vis-a-vis* their internal discourses and neighbouring disciplines. It is particularly important, I believe, that the effort to develop the disciplinary identity of the field is collectively undertaken to the extent possible, and I return to this point in Section 5.4 below (p. 150). Meanwhile, I will situate the following reflection

on the methods I have used in this research in the context of the affordances of aspects of the assemblage of outcomes to particular audiences

5.3 Methods

The overall documentation of this research comprises a combination of first person accounts, theorising, contextualising explanation, demonstrative images and video clips (albeit few), commentaries, patches, technical documentation and recordings. Clearly, I have brushed up against a number of disciplinary practices in putting this together, including various technical subjects, philosophy and cultural theory, musicologies and sound recording practices. I shall focus on my use of first person accounts, and the potential I see for such a method; the approach I have taken to the technical documentation of my work; and on the recordings.

5.3.1 First Person Accounting

These accounts take various forms. Those in Chapter 1 are written in a present tense, and concern activities not directly represented in the portfolio, whereas those in Chapters 3 and 4 speak more directly to the portfolio work, and tend to be in a (more distant) past tense. There are different appeals to methodological precedent that can be made to argue for the value of these accounts. Varela and Shear (1999) present a detailed argument for the value of first-person accounts as part of an attempt to integrate phenomenological insights into cognitive science, in order to provide for fuller understandings of consciousness, for instance. Meanwhile, there is a good deal of precedent to be found in the approach taken by Sudnow (1978) in *Ways of the Hand*. More recently, and closer to disciplinary home, Katharine Norman (2010) proposed the value of *autoethnographic*[4] responses as a way of better understanding the interaction of listeners and sound-based works. On a similar basis, I would argue, the idea of autoethnography has evident utility in revealing to oneself and

[4]It is instructive to note that autoethnography has been subject to some contention within ethnographic circles. Ownership of the term as it relates to the form and epistemological scope of enquiry has been disputed. On the one hand is a contemporary movement that concentrates on literary, narrative forms of writing and insists upon the emotional implication of the researcher in the account. On the other is a view that sees autoethnography also as a practice with precedents in more 'traditional' ethnography, able and willing to draw more generalised and analytic conclusions than the former camp (Anderson, 2006; Ellis and Bochner, 2006).

one's readers aspects of practice, motivations, overlooked knowledge. Taken in such a way, the research behind *Improvising Machines* by John Bowers (2003) also forms a precedent, although he couched the work in terms of participant-observation.

Given, though, that any analytical claims arising from these accounts are bound to be personal and partial, one may well ask on what basis they can be supposed to make any wider contribution than personal enlightenment, that is, as private goods. However, if we consider these activities as part of a process of developing a critical response to our practice, then an argument made by Richard Shusterman (2002) concerning Wittgenstein's thoughts on critical reasoning helps us along. Critical reasoning, by this account, need not be either inductive or deductive, but often takes a rhetorical form. Rather, the writer tries to persuade the reader of the value of seeing something in some particular way, with no necessary claim to the exclusivity or primacy of this way of seeing (although, of course, critics frequently do make claims for the primacy of their interpretations). Such a stance is highly productive as a non-normative basis for critically reflecting on our practice and for theorising the wider value of such an exercise. In order to do so, it may be useful to adopt an enactive stance (Varela, Thompson and Rosch, 1991) and position musicking, alongside other collaborative activities, as a form of collective 'sense-making' (De Jaegher and Di Paolo, 2007). One reading of 'sense-making' is, of course, quite compatible with an approach to art that concerns itself with meaning as expressed in works or practices, but bearing in mind enactivism's insistence that the world is something we 'bring forth' through our living in it (Maturana and Varela, 1992) it is, I think, equally compatible with an understanding that our experiences also literally *make* our senses. In this way, particular cultural competences are understood to be negotiated on the basis of members of interpretative communities being able to articulate, in some way, what they notice and value in an experience and in drawing others in to notice and value in similar ways, to become more *sensitive* to some particular saliences. I might be skating dangerously close here to the kinds of didactic, patronising propositions that (only) certain types of music are 'improving', but I think it is quite possible to advocate for this idea of sensual formation without being normative, by insisting, like Shusterman and Wittgenstein, upon the plurality and contingency of interpretations. On this basis then, it might be fruitful to approach this kind of first person writing about practice as an invitation—to fellow (or potential) practitioners in the first instance—to *notice*

in a particular, practical way, in the hope that this could be itself generative of practical realisations for the reader/do-er.

5.3.2 Technical Documentation

The main challenge in producing useful technical documentation is in deciding who and what it is for. There are two principal possible audiences. First, fellow practitioners who may be interested in the particularities of technique with a view to reusing or adapting them. Second, musicologists and/or practitioners further down the line who may be interested in putting work in some sort of historical context and/or trying to recreate a system in its entirety.

Each of these prospective audiences is likely to have different levels of technical comfort, and different material resources to hand in deciphering the documentation. A contemporary may well have access to the same software systems I have used (Max/MSP on Mac OS X), but this is hardly a stable guarantor of accessibility. The coming and going of digital platforms has shown itself to be extremely swift, such that there are acute obsolescence problems for composers who wish to have precise recreations of their work enacted in the future (Emmerson, 2006). Whilst I am ambivalent about musicking for posterity, even in the course of this research I have had to undertake significant re-development work on patches, as third-party objects have become unavailable with architecture changes to the way Max/MSP loads externals. Furthermore, a Max/MSP patch shows you how some boxes are connected. This may, in practice, only have a loose connection to what is going on algorithmically, especially if significant processes are shrouded in single objects. Finally, Max/MSP is a commercial system, so that even its continued existence does not guarantee accessibility.

Some form of additional explanation is called for. In approaching this, it seems that a balance has to be struck between completeness, clarity and appropriate emphasis. The challenges, described in Chapter 1, in interpreting the (quite thorough) documentation for Di Scipio's *Background Noise Study* arose, for instance, because there were assumptions about what to leave out which made sense in the context of the system the piece was designed on (Kyma), but were less clear when 'thinking' in Max/MSP. Problematically, when something is not working, but you do not know what, then a much greater level of detail suddenly becomes desirable in order to try and verify *everything*.

But what forms are suitable for communicating, as completely as is appropriate, the operations of a technical system? A reflexive response might be to provide mathematical descriptions of all elements. However, there does not seem to be any real basis to suppose that this would be the clearest presentation for most casual viewers, as some people are easily put off by mathematical notation. Moreover, it is perfectly possible to be mathematically ambiguous (by failing to be clear about assumptions, for instance).

Thinking on the issue of appropriate emphasis provides a basis through which to decide how much detail to include, and how to express it. In the case of these portfolio pieces, the determining factor is what I take to be the salient points of the system's construction. For instance, in ***And Now For Some Music*** two different pitch trackers are called for. In one sense, it doesn't matter at all how they work, so long as they are different: the idea is to make creative hay out of their disagreements. In another sense, however, a substantive part of the rest of the patch takes advantage of the fact that one of the trackers used also performs a segmentation so that Pitch Synchronous Overlap-Add (PSOLA) based processing can be performed. Even in this case, the actual method of segmentation is not as important as the fact that it affords some (distinctively unstable) dilations of time and manipulations of pitch. So, whilst trying to document the scheme as implemented as thoroughly as possible, it has seemed worthwhile to elucidate what would be a priority (for me) in re-implementation.

Following this through, then, the approach I have adopted in all the portfolio pieces is to combine flow charts with a technical commentary detailing what I see as relative priorities, and providing further illustration and mathematical description where it seems important.

5.3.3 Recordings

The approach I have taken with the recordings has been to try and strike a balance between completely unmediated documentary and something adjusted to sound more like I think it ought to, or did. A certain amount of equalisation is generally necessary to compensate for the difference in scale between a performance sound system and listening on smaller near-fields.

A recorded performance can come across as durationally changed also. When preparing fixed media pieces for diffusion, I would regularly experience this when playing back on a performance system: everything could seem

rushed, hunched up, and I would have to return to the studio to let things breath out a little more. Conversely, in unadulterated recordings of performances the pace of action can seem considerably more drawn out than it did at the time, as the silences and voids feel much emptier once removed from the original context of performance. Consequently, a small amount of equalisation to bring out detail, a drop of reverb to provide a floor, and dynamic range adjustment to rescale impacts are judiciously added to recordings to help restore them to fullness.

Beyond topping and tailing, I have not altered the clock-time relationships between events in any of the recordings. Doing so, it seems to me, *would* constitute a qualitative shift away from a documentary artefact. Furthermore, becoming involved with editing internal temporal relationships is a perilous enterprise: it is extremely easy to inadvertently edit away the vitality of a performance.

In assembling the portfolio as a whole, I have also tried to keep 'mastering' interventions minimal. The recordings were adjusted to sit around a nominal level of -17 LUfs[5], which leaves plenty of room for dynamics. Nonetheless, a limiter was employed to catch any stray peaks above -1 dBfs. A small amount of 'shaping' equalisation was also used to help harmonise the different recordings. Typically these were cuts or boosts of < 2 dB with very low Q (< 0.5) filters.

The balance to be struck, of course, is in not getting caught up into trying to make a new thing altogether. My rule of thumb has been to apply less rather than more intervening processing in each case. Yet, an inevitable tension remains, as with all recordings of improvised music, between the highly dynamic, vital situation that was captured, and the ossified form of the recording. The temptation in doing any kind of post-processing is that aesthetic priorities more centred around fixed media presentation, such as spatial articulation, begin to guide action. In and of itself, this would not be problematic; my reasons for avoiding it here are not bound up especially to an ideal of authenticity or a belief in the intrinsic veracity of an untreated recording. Rather, extensive production of the fixed media could blur the focus of the presentation somewhat, which is concerned primarily with the assemblage that contains and relates the systems-as-pieces, their documentation, contextualisation and theorisation, and their soundful manifestation.

[5]LU are 'loudness units' as defined by ITU BS.1770. This form of metering uses a very simple model of perceived loudness to improve on some of the shortcomings of straight RMS metering

There remains also an issue of canoncity that needs to be confronted. These recorded pieces are not simply of improvisations in that they are also documenting systems in action. As we saw repeatedly in Chapter 1, it is not always immediately clear whether a recording of something indeterminate represents what it *could* sound like or what it *should* sound like. As such, it needs to be acknowledged that I have exercised some sort of selective agency in determining which performances have been included in the portfolio, and the criteria of selection should be made apparent. As a generalisation, my selections have been based, quite simply but unscientifically, on preferring those renditions that I felt to be more *musical*. That is to say, those where I felt the dynamics of the computerised components *and* my soundful coping with these to have produced a more engaging whole. However, my preference for these versions should not be taken to indicate that they enjoy canonical status: the design of the software components is such that they should produce considerable variability, such that quite distinct but equally musical performances are available.

It will also be apparent to the reader that, in all but one of the portfolio recordings, I have elected for 'studio' versions (no audience). Specific discussion is given in Chapters 6–10 for each piece, but the same dual concerns apply in each case. First, I was at pains to ensure that the recording submitted was made on the version of the software submitted, as the differences between versions are quite pronounced. Second, where there have been live recordings, many of these have been problematic. In some cases, such as the renditions of ***Danger in the Air*** and ***And Now for Some Music*** discussed in Chapter 4, the recordings are useful for documenting a troublesome performance, but not indicative of the dynamics I was trying to achieve. In other cases, recordings have simply failed to happen or have been compromised beyond usefulness.

This raises a critical issue for research of this kind, in that it has become apparent that one really needs the collaboration of someone trustworthy and competent to take responsibility for recording performances. I have found it all too easy, when trying to record my own concerts, to simply forget to press record, or to end up with a poor recording due to my attention not being focused on the technicalities of making a good recording (for instance, free of clipping). The same applies to taking recordings from front-of-house mixing desks, in that the sound engineer has other things to attend to and it is easy to end up with something unusable. As such, there would seem to be

a good case for making it standard practice that researchers team up, where they can, and agree to document each other's performances. The benefits of making this a longer-term arrangement go beyond merely ensuring that one has usable recordings, as it represents an opportunity for us to learn more from each other about approaches to recording *in practice*.

5.4 Conviviality

> I choose the term 'conviviality' to designate the opposite of industrial productivity. I intend it to mean autonomous and creative intercourse among persons, and the intercourse of persons with their environment; and this in contrast with the conditioned response of persons to the demands made upon them by others, and by a man-made environment. I consider conviviality to be individual freedom realised in personal interdependence and, as such, an intrinsic ethical value (Illich, [1973] 2001).

I am going to end this chapter by considering the issue of the public situation of live electronic and electroacoustic music research from a seemingly strange angle, by focussing on our *intra*-disciplinary communication.

From within the field, the most detailed and sustained consideration of the appreciation of electroacoustic music has come from the work of Leigh Landy over the last two decades, which I shall review briefly. Landy focusses his concern on the extent to which electroacoustic musics afford what he calls 'co-hear-ence' by offering listeners 'something to hold on to' (Landy, 1994, 2007, 2000). His discussion takes a wider frame than locating such affordances solely in the sonic surface of musical experience, and acknowledges the interpretative agency of listeners. His recent focus has tended to be on how a piece's 'dramaturgy'—explanatory, presentational aspects of musical experience—is formative in the dynamic between compositional intentions and audience reception.

On occasion, Landy has linked these concerns in with criticism of the general tenor of electroacoustic discourse. For instance, he situates problems with 'co-hear-ence' and the lack of things to hold onto as arising from an 'island-mentality' within the discipline that interferes with an orientatation towards 'holism', that would be able to account for the emergent, aggregated qualities of the field in situ (Landy, 2000). Elsewhere, he is also critical of a related tendency towards radical individualism, which gives rise to an 'over-abundance of musical languages' (Landy, 1996, 65) that are not sufficiently shared. Such individualism detracts from 'co-hear-ence', even among specialist

listeners. It is through these concerns with holism and shared language, as relational aspects of our disciplinary communication, that I wish to approach this issue.

We can do this through a return to Ingold's framework of dwelling and commodity perspectives (see Section 5.1.3, p. 132). Recall that Ingold argues that the dynamics of human conduct under industrial capitalism are better accounted for by considering the relationship between these perspectives as dialectical, rather than oppositional. The commodity perspective, as manifested in our institutional and ideological structures, tends to produce oppositional classifications of phenomena that may, in practice, be fuzzier in their distinction. It is left to people to cope with whatever mismatches, elisions and frictions arise as a result of the shortcomings of such mappings.

A number of such distinctions are operative in discourses around the cultural position of electroacoustic music. Most obviously present is an oppositional discourse at work between what Simon Frith calls 'bourgeois art music' and 'commercial music' worlds (Frith, 1996, 36–42)[6]. This dichotomy tends to arise when commentators argue in terms of the cerebral qualities of art music, in distinction to the bodily preoccupations of, say, dance music (and we see how dualisms of mind versus body and high versus low culture arise also). Similarly, the distinction is apparent when proposing such an entity as the 'creative industries' that manages to attract revenue, in distinction to marginal practices that rely on patronage. In practice, this distinction glosses over a great deal of musical activity, eliding the ways in which musicians are, and have historically been, nomadic between institutional worlds.

There is also a tendency to harden an opposition of professional versus amateur, as legitimating claims of expertise are made in the service of either art or commercial music worlds. Even if the claims to expertise are justified on different bases, they have in common a universalising quality that, again, fails to account for the considerably more complex tapestry of lived practices. To the extent that both art and commercial music worlds are buttressed by institutional supports, both become performative in coming to specify the cultural horizon of musical discourse, and technocratic in necessitating musicians to account for their practices in commodity terms that are not arrived at democratically.

[6]Frith has a third category, folk music. It is possible, I think, to see his description of folk music discourse as an idealised enactment of musical dwelling that flounders on its inability to account for commodity perspectives.

These kinds of oppositional discourses, I contend, contribute not only to a hardening of inside-outside academia boundaries, but also interfere with the quality of our communication within the discipline. One way, among others, to improve the qualities of both internal and external communication is based on the supposition that a great many participants in the discipline have rich and varied musical lives in wider contexts that are not accounted for in our formal discourse[7]. There are three aspects to this.

The first aspect considers the problem of shared musical languages from the perspective of musical histories. Recent years have seen the admission of researchers and students to electroacoustic academia from a wider range of backgrounds than a traditional art music education, myself included. This presents a need to cope with the diversity of backgrounds in practice, relative to more slowly adapting institutional ontologies. Canonical histories of electronic and experimental music remain almost exclusively concerned with the histories of art music's avant garde, which provide little by way of a template for communicating about musical practice in other terms (and so, not much incentive to talk about something other than technology). However, musicians have a range of informal ways of dealing with diversities of influence and background, such as through the exchange of recommendations, mix tapes, scores, and playing together. Meanwhile, diverse approaches to traversing musical histories with words, in idiosyncratic, yet evocative and communicative ways, have been tried out, for instance, by Katharine Norman (2004) and Kodwo Eshun (1998).

There are, I think, a range of possible tactics available that could combine or fall between the exchange of mixes or play-lists, the preparation of idiosyncratic textual traversals and the production of conventional linear histories as ways of improving the musical scope of our internal discourse. Some of these may be less formal and more ephemeral, as part of some larger documentary assemblages, or as part of the support dramaturgy for a work, performance or presentation. The point is to find ways of normalising the inclusion of broad musical sweeps into our communication, in order to improve our basis for being able to describe, think about and do such music, to provide a fuller accounting of the cultural situation of our work, and to incrementally un-erase those strands of practice that continue to be unaccounted for in established narratives (Lewis, 2004).

[7]An informed supposition nonetheless: I have not met any colleague for whom this is not true.

I have deferred mentioning a particularly obvious way that musicians exchange musical histories and understanding, which is through co-practice. I am concerned here particularly with co-practice as an orientation towards communication and exploration, where outcomes in the form of works or public performances are of secondary concern. Again, this is something that takes place informally, but that would merit being considered a more routine aspect of our scholarly exchange. Some small steps in this direction have been taken already through a series of practice-led symposia that I have been involved in running with a group of postgraduate researchers from the University of Edinburgh. These have occurred under the banner of Laboratory for Laptop and Electronic Audio Performance Practice (LLEAPP), held at the Universities of Edinburgh (2009), Newcastle (2010) and East Anglia (2010); funding is currently being sought to continue the initiative (see Section 1.2.2, pp. 49–53, for an account from the first LLEAPP) . The format of these has been that small groups form to devise a performance together over the course of a couple of days. This seems to be a promising approach, but still requires a degree of development. We were over-optimistic at first that, as groups of fellow researchers, it would be easy to self-organise and to devise space for regular critical reflection. However, it seems that some degree of workshop-style facilitation is still needed, at least in the early stages, and that a clearer sense of protocol and possible documentary tactics would help participants.

The third and final aspect, drawing on the first two, concerns the breadth of activities that feature in our communications. My experience has been that practice-led researchers, like musicians in general, become involved in a wide range of musical practices, many of which are not directly connected to their research projects, but that, nonetheless, inform and are informed by their research. We work as session musicians and collaborators in diverse genres and settings; as sound and recording engineers; DJs; community musicians; and teachers, among other things. My contention here is that by finding ways of including these activities in our discourse (which, nevertheless, may stop short of integrating them into research projects), we will be better able to understand the extent, nature and potential of public engagements that already occur and, furthermore, be better able to formulate ways of researching through such public musicking, and have more to offer interdisciplinary colleagues in understanding the movements of music and music technology in a variety of settings.

All these three rough proposals suffer from running against the grain of current political imperatives of academic research, however. By being orientated towards communication, not production, their value will not be immediately apparent from the perspective of institutional prioritisation of research that produces tangible unambiguous outcomes, preferably with clear potential for commodification. Similarly, my three suggestions are all predicated upon a collective understanding of the research endeavour, rather than a competitive one where researchers themselves are commodities. Whilst this orientation is quite conscious, it does leave unanswered the question of what incentive there could be to adopt such practices, given the extent to which they may conflict with what some feel to be necessary attention to self-promotion and individual differentiation. I am pessimistic about the effectiveness of a group of competing individuals in challenging the trend towards ever more hostile and alienating working and learning conditions, and in this sense see some form of collective discourse that can present a coherent and united alternative account of how music could be approached as an urgent matter. Although my suggestions run against the hegemonic grain, my hope is that they do so in small enough ways, within our margin for manoeuvre, to be practicable and effective in developing the basis for a more cohering and co-hearing discipline in the future.

5.5 Summary

To evaluate the effectiveness or appropriateness of documentary strategies for practice-led research, I argue that it is necessary to have an idea of who the various outcomes and documentary traces are aimed at. To uncover this, I suggest that practice-led research in live electronics forms an assemblage of 'club goods', aspects of which may be of potential interest to a range of other researchers and practitioners. The potential relevance to fellow researchers is conditioned by the interdisciplinary status of live electronics, and I propose that there is scope for productive agonism with both musical and allied technical disciplines.

With this in mind, I have paid particular attention to discussing the use of first-person accounts in my writing, as I see these as fruitful both as a means of communication and exploration with fellow practice-led researchers, and as a medium of interdisciplinary communication well-suited to the scope of practice-led research. In considering the approaches I have taken to my tech-

nical documentation and recordings, the potential diversity of the audience widens somewhat, so I have felt it necessary to be reasonably explicit about the broad rationale for the choices I have made.

I defer considering a potential audience for this research outside academia until the final section, only then to approach the question somewhat perversely as an aspect of intra-disciplinary communication. The basis of my argument is that on an individual basis many practice-led researchers enjoy frequent and appreciated public engagements, but that these are under-represented in our formal discourse. I suggest that part of the reason for this is an excessive discursive proclivity for technology rather than people, but also that our canonical histories—which have some role in determining the scope of discourse—are inadequate in scope to account for the diversity of musical experience and nomadism in the field. I propose, speculatively and non-exhaustively, three possible ways of expanding our formal discursive practices to help remedy this. First, by exploring ways of making co-practice itself a method of scholarly communication. Second, by expanding the music-historical scope of our discussions by imagining ways of formalising the exchanges of mixtapes and playlists common amongst musicians. Third, by consciously including in our documentation of practice more work that takes place outside of the assumed default of the experimental chamber music setting, and so more comprehensively accounts for the diversity of musical situations in which we find ourselves.

Conclusion

Improvised Musicking, Technology and People

This dissertation has traced, from a number of vantage points, different tendrils of activity and thinking that have informed the improvised electronic musical practice formed over the course of this research. A principle motivating factor in the conduct of this research and its documentation has been to preserve a sense of musical practice as something that overspills the boundaries of works and performances, and to try and capture an impression of the meshwork of social and material relationships that situate and constitute such a practice.

As such, the approach taken has been both *phenomenological* and *pragmatic*, insofar as I have remained focused, to a great extent, on the phenomena arising from my own practical experiences of musicking as a basis for theorising those same experiences. Whilst a pragmatic disposition has tended to militate against the development of a singular ontological optic through which to explain these experiences, instead preferring to admit of multiple, coexisting ontologies, a generally *ecological* viewpoint has been present throughout that finds interest in the shifting, relational nature of things. As the relationships I have encountered and participated in have been between people, and between people and technologies, I have found myself interested in the *performativity* at work as these relationships are enacted and negotiated, and in the implications of such performativity for my preference for broadly *non-hierarchical* musicking. Taken together, this research has been able to make contributions to practice-led research in live electronic musicking both in form and in method.

In Chapter 1, the autoethnographic focus serves as a useful tactic for evading ontological approaches to defining composing and improvising that I take to be quite unhelpful from a practical perspective, insofar as they invite the

establishment of oppositional categories that run counter to experience. By electing instead to focus on my own experiences of musicking with and without composed direction, I am able to get at useful detail and present robust examples of ways in which people, technologies, texts and other materialities interact in musicking. As such, this chapter offers a novel theorisation of a number of issues around live electronic musicking, as well as a novel method for approaching these questions. I am able to usefully extend the argument made by John Bowers (2003), and to provide a new optic for live electronic music by applying the framework developed by Steven Feld, 1984.

The approach taken in Chapter 2 is more orthodox in its presentation, but nonetheless contributes to the theory of electroacoustic music. In it, I build upon work by Waters (2007), Magnusson (2009), Feenberg (2002, 1999), Ingold (2000) and others to develop further a philosophy of music technology that is socially rooted. I offer what I hope is a robust argument against the easy tendency to treat digital musicking as wholly different, incommensurate even, with other forms. In so doing, I develop a socially grounded account of musical skilfulness that rests on an environmentally situated notion of *wayfinding*. The idea here is to propose an understanding of musical technology that readmits both players and other musical participants into the technological account and that dispenses with any chauvinism about what form such technologies take. Finally, I re-conceive musical-technical virtuosity and novelty in less historically burdened terms of *agility* and *playfulness* respectively.

Chapter 3 begins the process of reflecting upon the contribution made by the portfolio pieces, and follows on from Chapter 2 by focussing on technology and skill. To this end, I follow Sudnow (1978) in approaching the development of my various performance ecologies from a phenomenological perspective that yields richer results than purely technical description. In particular, I am able to bring in to relief certain resistances encountered along the way and discuss how these shaped my work. Whilst similar to the approach of Chapter 1, and of Bowers (2003), these accounts are, I believe, novel in their contribution to electroacoustic discourse to the extent that they confront the particular, lived challenges of reconciling the practical necessities of engineering practice and of creative work of a sort that are inevitably encountered in the process of translating ideas to code (for me, at least). This is a perspective on technology that electronic musicians, and other technologically embroiled artists, are very well placed to develop, and serves, I believe, as a valuable complement to

more abstract technical writing insofar as it develops a discourse of practical solutions to practical problems that may not be solely technical.

A similar approach is taken in Chapter 4, this time with respect to performing. I examine the particular ways that experiences of performance folded back into my work form the perspectives of my bodily orientation, the handling of time, the relationship with loudspeakers, and between different contexts of performance. In each case I was able to shade existing accounts with the particularities of my own experiences. With respect to the handling of time, I discussed briefly novel approaches to the handling of macro-time taken in the portfolio pieces. The existing discussion of loudspeakers has tended to be rather thin and technically orientated; in keeping with my focus on the socially situated nature of technology, I have added to this discussion by sketching out the ways in which our relationships with loudspeakers are also social. Finally, in noting the differing musical affordances of different types of performance context, I make an appeal for the value of enlarging the scope of our performance contexts such that they might present musically worthwhile challenges and a richer understanding of our practices in social context.

Chapter 5 presents a new consideration of live electronic music as research, and in doing so presents a novel synthesis of theories from the discourses around practice-led research and interdisciplinarity. The chapter closes with a somewhat speculative, but nevertheless important, discussion of ways in which our formal discourse could better represent the richness and scope of our musical relationships with the world outside academia.

Further Work

Chapters 3, 4 and 5 each outline areas in need of future research. In Chapter 3 I point to a need for more work that confronts the transition between designing and musical practising, and note some fertile areas to investigate different ways of dealing computationally with highly non-stationary sounds. Chapter 4 ends with a suggestion of the worthiness of documenting practices across more diverse interpretative settings and describes continuing attempts to bring some of the autonomous-machinic techniques I have developed in this research to my live hip-hop project, *Sileni*. It also identifies a need for further discussion of coping strategies for live performance with loudspeakers, and for continued development of computational methods for dealing with musical macro-time. Chapter 5 makes a number of proposals concerning the

conduct and orientation of practice-led research in live electronic musicking. In terms of our interdisciplinary relationships, I call for a more agonistic and critical, but nonetheless constructive, approach to exchanges with allied technical disciplines such that the different ways of knowing that are afforded by practice are able to complement the functional perspective of designers and engineers. With respect to other musical sub-disciplines, I argue that there is a need for practice-led research to engage more fulsomely with the wider endeavour of musical research and to be prepared to argue for the value and contribution of practice approaches. Finally, I make some suggestions about the intra-disciplinary formal discourse of electroacoustic practice-led research orientated towards reaching fuller understanding of each other as musicians and cultural subjects. To this end I propose the possible value of integrating in to our formal methods of communication co-practice (as I have been involved in starting to do with a series of symposia), the sharing of diverse musical histories, and the drawing in of the full variety of musical sites and social contexts that we, as practitioners, find ourselves musicking in.

Inevitably, these suggestions overlap to an extent, and thus suggest some broader, overall themes. One of these is a repeated call in the text for the tenor of discourse in live electronic research to shift away from functional accounts of technology and to establish practice itself as a guiding thematic, on the basis that such a shift would enrich both the sub-discipline and our communicative potential with colleagues. This dissertation has been an attempt to do just that, and hopefully provides a useful contribution both in form and content. However, there is no reason to suppose that such a change might come about spontaneously; what is required, it seems to me, is the establishment of a space for such a discourse to be developed within the sub-discipline as a complement to the practice-led symposia discussed in Chapters 1 and 5 that concentrates on accounts and theorisations of practice that deal with the full breadth of the analytical framework offered by Born (2010a) and encompasses social, temporal, technological and ontological aspects of live electronic practice, whilst respecting and developing a discourse of robust pluralism. I made a start in this direction in 2009 by organising a one-day conference at City University London as part of the AHRC's 'Beyond Text' scheme, entitled 'Outside the Box: Practice, Participation and Method in Live Electronic Music', and hope to be able to organise further such events in the future.

In terms of musical projects, the areas for further work coalesce into four main priorities: the development of further tactics and techniques for multiple-

player environments; the investigation of longer improvised musical forms; the integration and handling of sampled materials; and the development of musical approaches amenable to diverse interpretative settings. These vectors each bring with them a mixture of practical, technical, methodological and theoretical commitments. It is my hope that in a future project I will have the opportunity to develop these areas through the composition of a long-form piece for my duo *Sileni* in collaboration with a wide range of other players from my community of practice.

Part II

Portfolio Commentary and Technical Documentation

Chapter 6

Danger in the Air

6.1 Commentary

Danger in the Air (2006) is an improvising space for a performer (or possibly more), interacting with the electronic component through a Soundfield, surround sound, microphone, with the aid of objects of limited musical potential, known as *infra-instruments* (Bowers and Archer, 2005). Most often, I use *infra-gongs* (see Section 3.4.1.1, p. 95) in the form of track shelving brackets—along with direct handling of the microphone—as my central sound making means.

The electronic component, meanwhile, is driven by the sound coming into the microphone. It tries to remain ambivalent about the *source* of a sound. There is no hard-coded assumption of a musical agent being present, nor of any particular kinds of sound to expect, or of any particular inferences that can be drawn from particular input. Instead, the system exists in a feedback relationship with itself, mediated by the space and any other sound making bodies in it. The steady state of the room-microphone-computer-loudspeaker-room loop is a gently modulating and mutating texture, punctuated occasionally by more direct sayings.

The player, then, intervenes upon this steady state, but at a remove. The response of the electronics is neither to return immediately a processed version of the player's sound, like an effects unit (though it may); nor to articulate its own gesture clearly congruent with the player's, like an electronic instrument (though it may); nor (even) to adjust itself in a musically sympathetic manner, like a co-player (though it might, and we hope that by and large it will).

Instead, playing with these electronics is a negotiation between these three modes, of processor, instrument and co-player.

The system processes with varying degrees of delay and at various time scales to changes in its sonic environment. Although all the sounds it produces are re-assemblages of previous input, quite what they will be (and from when) is an unpredictable matter. It is most like an effects processor when what remerges is temporally and spectrally close enough to the player's current activity, like an instrument when there is an audible (or, in performance, visual) correlation of shape of more distant or radically processed material, and like a co-player when it appears to be responding and imagining its own shapes.

Because the system is constantly chewing on whatever signal the microphone picks up, and not just the actions of a player, it is able to contribute in ways sonically distinct from the materials that the player brings. Furthermore, because it is recirculating sound, we are able to hear events circulate iteratively, mutating appreciably each time on their way through acoustic and computational space.

At work in this piece is a quite deliberate juxtaposition of technological strata, by building a performance around a combination of a high prestige microphone, advanced digital processing and quite purposefully limited sound making means. Part of the point is to insist on the contextual sensitivity of technological status—DIY equipment can be elevated, whilst precision sound recording equipment is, perhaps, debased. Certainly, the direct handling of the microphone performance is intended as a small heresy.

Meanwhile, the approach taken to the signal processing reflects my ambivalence at the extent to which the ways that we imagine electronics as instruments or performers can serve to reify particular ideals, with the possibility that musically interesting things fall between the cracks of these categories.

6.1.1 The Recording

The version presented in the portfolio is a studio recording made at the University of Edinburgh in 2013. Whilst there have been public performances at the ICA, London (2006) and the University of Edinburgh (2007), neither was terribly successful (see Chapter 4) and, moreover, the patch has since been completely reimplemented to deal with obsolete Max/MSP objects and to improve longer-time-scale dynamics.

The session was recorded in a large room ($\sim$360 m^3) in the University of Edinburgh's School of Music that is used as a combination of storage and workshop space, rather than a dedicated studio. Despite its size, it has a relatively dry acoustic due to the degree of clutter and other absorbing material present. It is also not a totally private space, as 'studio' might imply, as people are regularly coming through to fetch equipment, and it is surrounded by practice spaces from which it is not acoustically isolated.

For the session, I set up the Soundfield microphone around five metres from a pair of Genelec 1031 loudspeakers, raised around 2.5 metres from the floor. A further pair (for 'diffuse' components of the computer sound, see below) was positioned around a metre behind the first, firing at the wall).

The take selected was the fourth complete run-through (although there were many false starts), and the final performance of the session. That is, I stopped when I was satisfied and committed to a 'keeper' there and then, without a further audition session. Earlier takes had featured electronics that were either too sluggish or too responsive (so prompting some adjustment of gain stages), or had featured playing by me that was either too tentative or too excitable.

Although the internal signals to the patch are all in four-channel ambisonic 'B-Format', these are decoded to stereo in the patch to three separate stereo streams of varying gestural 'locality'. These three streams were recorded separately to disk for mixing, using the Metric Halo 2882's built-in recorder. In post-processing, some slight volume automation was applied to control peaks that sounded too aggressive in the studio. In addition, each stem had some light upward compression applied to bring out detail, and some downward compression to limit peaks further. EQ was applied to each stem, mostly to control the high-mids, which the feedback processes had tended to build-up somewhat. A small amount of reverb (850ms, no early reflections) was applied to help the stems gel.

6.1.2 The Performance

Although in my early relationship with this system I had tended to bring to bear as wide a range of infra-instruments as I could gather, for this performance I took a much more restricted approach and concentrated solely on shelving brackets and direct handling of the microphone because more varied approaches seemed to give rise to a more disjointed, fidgety, yet homogeneously dense affair. This was more to do with the direction of my attention, I

think, than with the electronics, in that having a wealth of possibilities meant that I was prone to concentrating more on what to do next than on listening and acting sensitively.

The restriction, then, serves as an attempt to dwell in a more consistent sound world, and to give myself less to do other than coping with finding music with this system.

The performance starts with direct handling. The computer produces soft impulsive atoms in response, and an occasional burst of resampled room tone. A longer burst of resampled room on a short loop at 1'07" prompts me to shift to the infra-gongs, alternating between striking a pair together, and rattling them on my table, leaving a fair amount of space between gestures. Meanwhile, the electronics produce occasional responses that are dilated slightly in pitch and time.

The gong gestures get more condensed, and the computer begins to have more to say for itself. At around 3'24" some feedback ringing occurs (as the dry level was pushed up for some reason), which gets damped before running out of control, but can be heard recirculating for the next minute or so, whilst my gestures get more drawn out again. Between 4'19" and 4'51" the computer takes a small solo, recycling and looping room tone, and sounds of earlier impacts.

At 4'51" the intensity starts to rise, with the computer's blocks of slowed down collisions being joined by layers of pitch shifted grains of gongs, and trails of impulsive texture. At 6'32" I attempt to bring this to a head by starting a protracted gesture, rubbing two brackets together, which the computer gradually takes up. I eventually stop at 7', and the computer continues with drawn out versions of this gesture until suddenly giving out at around 7'20", leaving a brief breath of clicks. A long, low swell emerges at around 7'28" as a prelude to a brief passage of more intensity as live gongs get swallowed up in a field of resampled gonglets and bassier chimes.

At 8'32", I start producing small tapping gestures, and space emerges. The computer joins in with a distorted, broken up almost-tone at around 8'50". More high impact impulses at 9'30" start an exchange of impacts high and low, with the occasional creak.

A bell like series of strikes on the gongs from 11'32" brings in the start of the most intense section of the performance. As steady strikes get picked up and chewed by the computer, a texture of inharmonic impacts builds up, before disintegrating with a melody of ever higher squeals (from feedback

again) at around 13'. My strikes become sparser, and the computer changes tack, re-serving the previous texture, but slower. It starts to run out of energy, and I call a halt as it produces a series of tight, high speed loops as a final flourish.

6.2 Technical Documentation

6.2.1 Quick Start

Danger in the Air is a piece for single player with miscellaneous objects and Soundfield microphone.

You will need:

- A Soundfield, or other B-format mic (you could perhaps just use Mid-Side (single, double or triple) to similar effect).
- Loudspeakers, preferably six. A pair is ok.
- Objects: shelving brackets, guitar strings, fingers, electric toothbrushes, anything else.

Setup:

- Arrange the microphone so that it is at a good height and distance to touch.
- Make sure you can get at your objects easily and quickly.
- Loudspeakers: if you are using 6, should have 5 and 6 forming the wide side of a trapezoid upstage, possibly facing backwards. 3 and 4 should be toed in further downstage, but still behind performer. 1 and 2 should be near the performer, either as a stereo pair, or a pretend dipole, with the polarity flipped on one, which is aimed upstage. See Figure 6.1 for a plan of this arrangement.

The piece chews on the sound you put in, and the room's response to that. You'll hear textures that are more local sounding, some that have more of the reverberant qualities of the space. These will shift between the rearward speakers if you're using all six.

Playing techniques should include direct (but gentle) handling of the microphone.

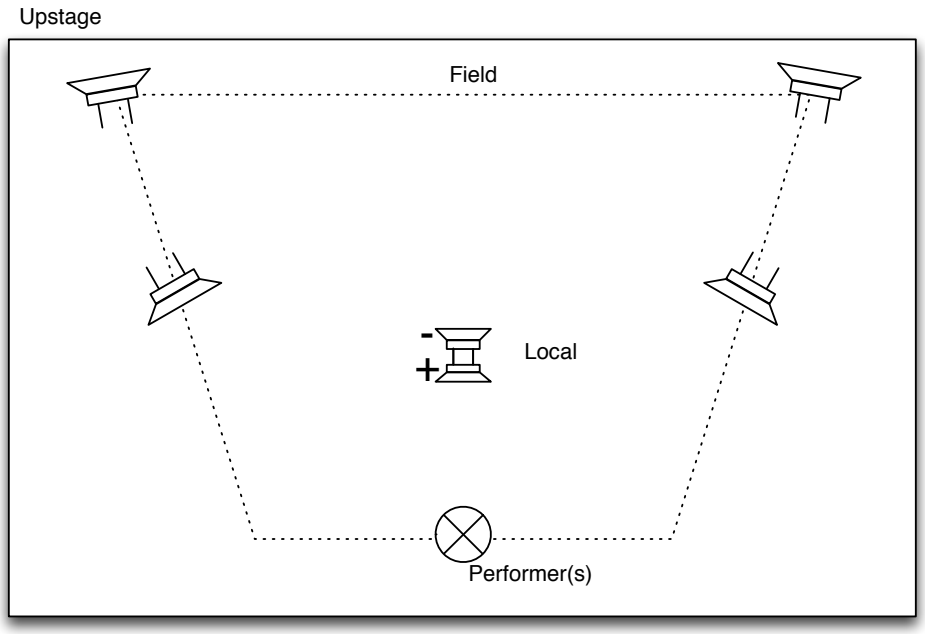


Figure 6.1: Plan of suggested layout when using all six loudspeakers.

The system is quite sensitive to input and output gains, and different combinations will result in different dynamics. As such, having a desk on stage that offers some immediate control over the gains has benefits, although doing this for all four channels of the Soundfield can be tricky. Feel free to add a gain stage into the patch and control via MIDI/OSC if that seems preferable.

If things are too hectic, turn one of the gains down. Vice versa, if you don't seem to be getting much dynamic response from the computer.

Press reset to clear all memories and start from scratch.

6.2.2 Overview

An overview of the signal flow can be seen in Figure 6.2. Incoming audio from the Soundfield microphone is in 'b-format'—a four channel format for surround sound (Rumsey, 2001). The signal is processed in two broad ways, with granulators and with samplers, and is also used to derive a set of control signals that drive processing.

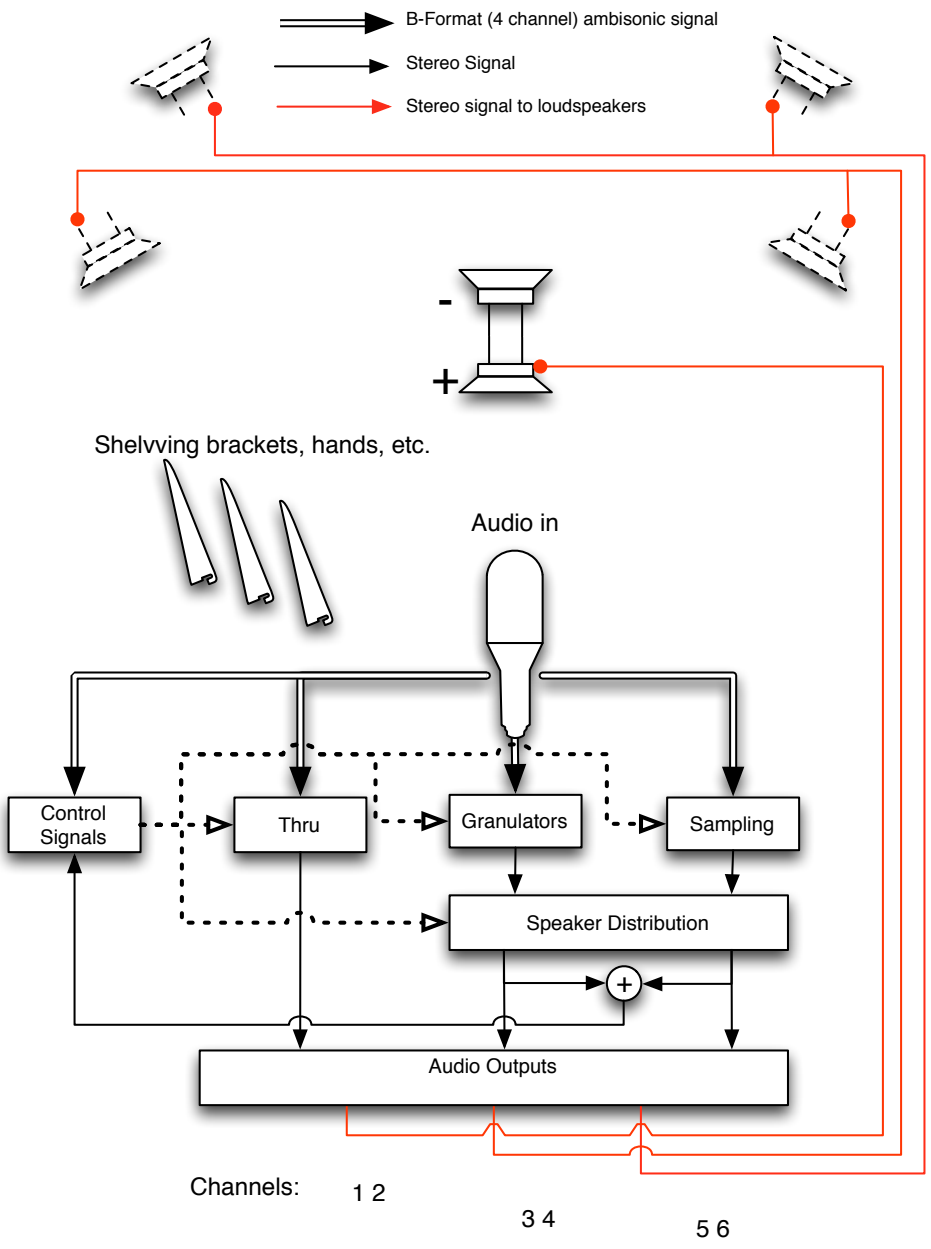


Figure 6.2: Overview of signal flow for ***Danger in the Air***

6.2.3 Control Signals

It is the derivation of the control signals that drives the character of the system (see Figure 6.3). Broadly, there are two types: envelopes and timing estimates.

Envelopes are measures of incoming energy at different timescales. **fastEnv** is a fast moving envelope, **slowEnv** responds more gradually. These are both derived in a similar way using a leaky integrator and a comb filter (see Figure A.1 in Appendix A, p. 244). **transEnv** is a series of impulses that mark the position of detected transients (see Figure A.2 in Appendix A, p. 245).

Timing Estimates are attempts to derive sensible(ish) underlying pulses to the action that help govern the timing of the computer's sound making. **shortTime** and **longTime** both use an autocorrelation based measure (see Section A.3 in Appendix A, p. 244). The values used here produce estimates around time scales of around 500ms and around 20s respectively. A third timing measure, **specTime** is based on the amount of time between zero-crossings in (low pass filtered) signal, and returns values in the order of tens of milliseconds.

In addition, the **localField** control uses a scheme by Merimaa and Pulkki (2004) for estimating how spatially *diffuse* the input signal is, as a rough indicator of whether the computer is hearing a player (assumed to be local to the microphone) or itself / some environmental sound (assumed to be out in the diffuse field). This is derived using all the inputs from the Soundfield, which can understood to be a pressure signal, p and three particle velocity signals, treated as a vector $\mathbf{u}$. The expression used is:

$$d = \frac{\sqrt{2}||\langle p[n]\mathbf{u}[n]^2\rangle||}{\langle p[n]^2\rangle + 0.5\langle \mathbf{u}[n]^2\rangle}$$

Where $\langle . \rangle$ denotes time average (I use a 100ms window), $||.||$ denotes the euclidian norm of a vector $y = \sqrt{\sum_{i=0}^{n} x_i^2}$. $p[n]$ is the W (omni) channel from the B-format signal, and $\mathbf{u}[n]$ is a vector made up of the X, Y and Z channels.

Finally, **envResample** is a buffer of shared sample memory that the envelope control signals are written to, and can be read back from at variable speeds—essentially a sampler for control signals. **grainTablePos** is a sinusoid driven by **longTime** that controls where in their delay lines the granulators read from.

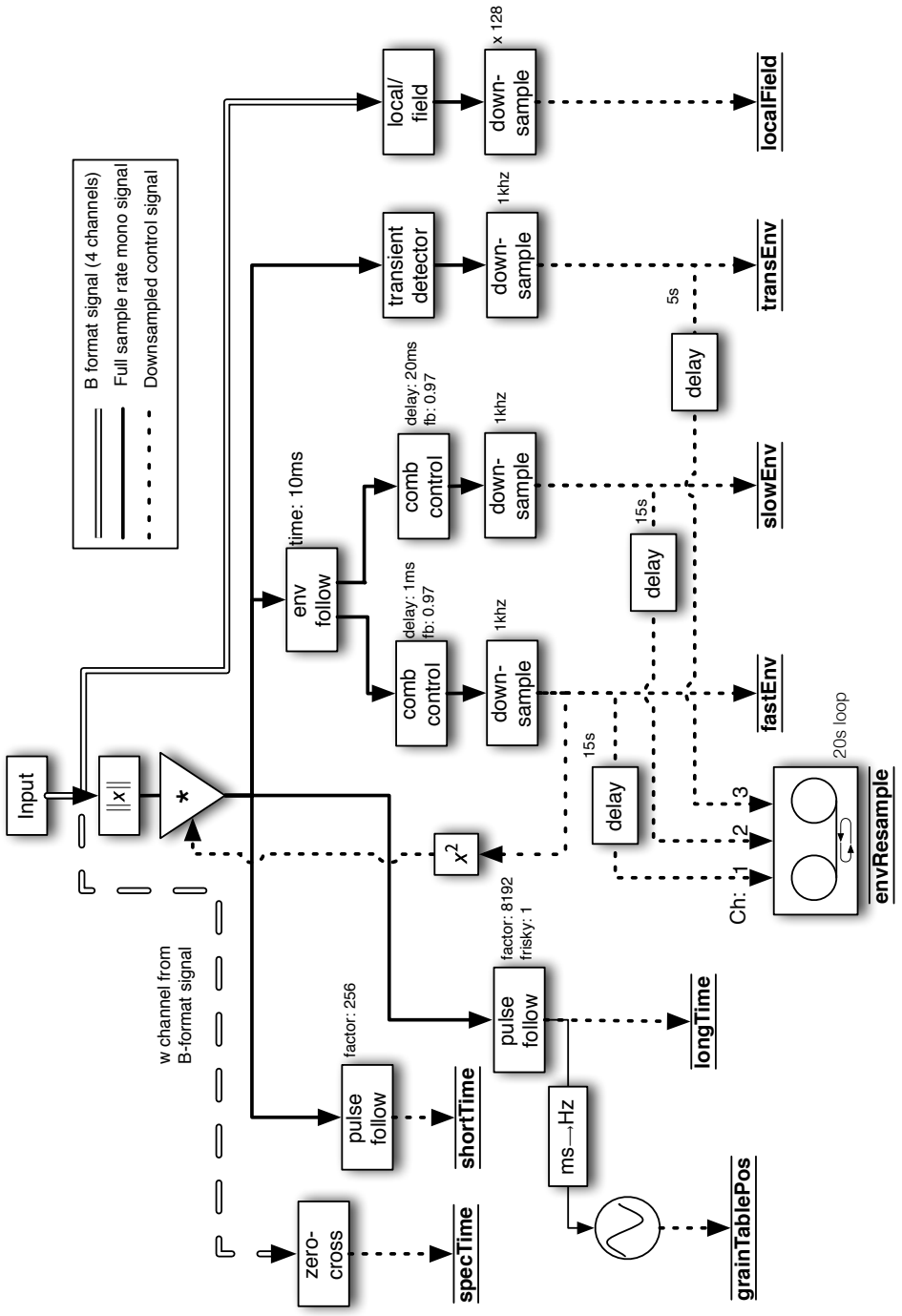


Figure 6.3: Deriving the control signals

6.2.4 Granulators

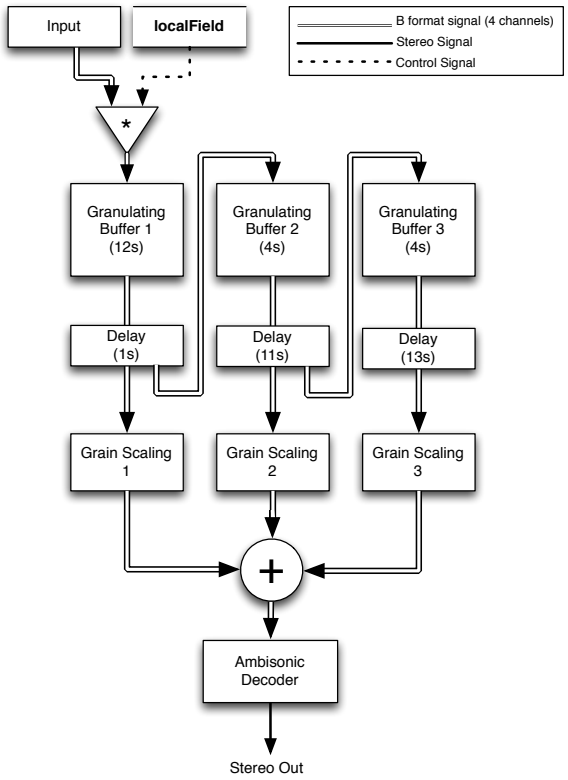


Figure 6.4: The chain of granulators

There are three separate granulators in operation, the second and third operating on the output signal of the one before, so that you have grains-of-grains and grains-of-grains-of-grains (see Figure 6.4. The outputs are delayed by different fixed amounts, and amplitude modulated in different ways for each stream. Finally, the B-format signal is converted to stereo for playback.

Each granulator is driven by the control signals in a different way that produces a different sound world. For example, Grain Buffer 1 fires a grain at a rate driven by $\frac{1}{8}$**specTime** $\pm$ some jitter from low pass (5Hz) pink noise. The rate is only updated at **longTime** intervals, giving the output a synchronous quality.

The transposition and grain length are driven from the same quantity as the trigger. The transposition is calculated on the basis of the ratio between the current and previous value of the trigger rate, folded into a two octave range and quantised to intervals in Partch's 43-tone scale.

The grain length is inversely proportional to the trigger rate, and varied between 0.5–80ms. The amplitude of the grains is derived by reading backfastEnv from envResample at half-speed and multiplying this by (1-**localField**.

Please refer to the code for details of the similar ways that the parameters for Grain Buffers 2 and 3 are derived.

Each granular signal is then amplitude modulated, also driven by the control signals. Figure 6.5 shows the signal flow for this amplitude modulation on Grain Buffer 3.

6.2.5 Samplers

There are two distinct samplers, both of which read from the same 10" buffer (Figure 6.6. The buffer is mono, using just the W channel from the input. It is highly compressed on the way in (see Figure A.4), such that in periods of quiet the room tone is inflated to audible levels. The output of each sampler is then re-enveloped to restore dynamics.

The samplers are triggered in bursts, rather than being constantly present. One is triggered when **localField** drops below a threshold, the other when **localField** exceeds a different threshold. One sampler reads back very slowly (around 0.25x speed), to inject low frequency content into the mix, the other at a high rate (around 4x speed) to make shriller textures. These speeds are modulated by a ratio of **shortTime** and **specTime**. The envelope of the low sampler is controlled by $(1 - \mathbf{slowEnv})$; for the fast sampler, **fastEnv** is read back at 0.25x speed from **envResample** and an envelope dervived from the expression $1 - \sqrt{x}$.

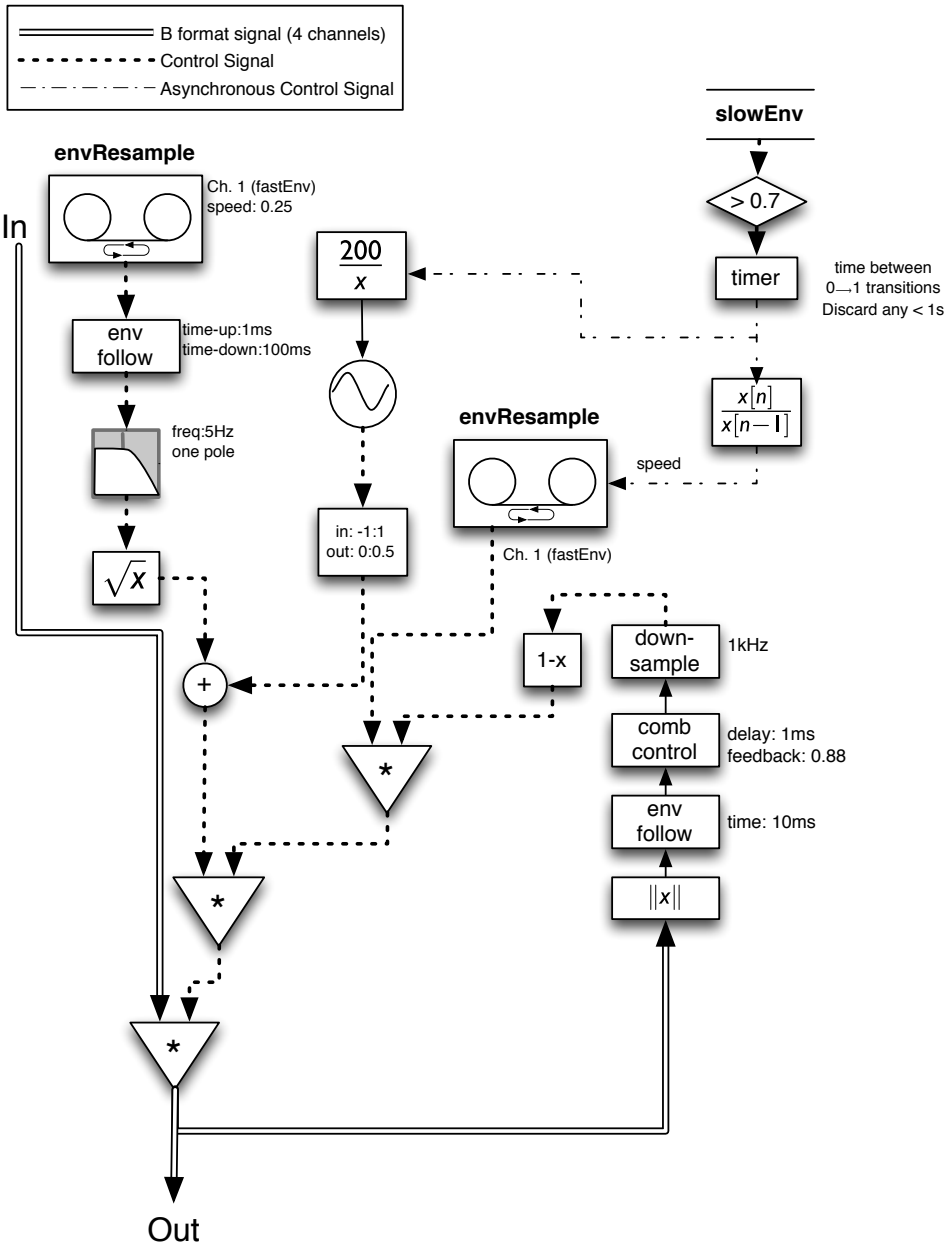


Figure 6.5: Amplitude scaling for Grain Buffer 3

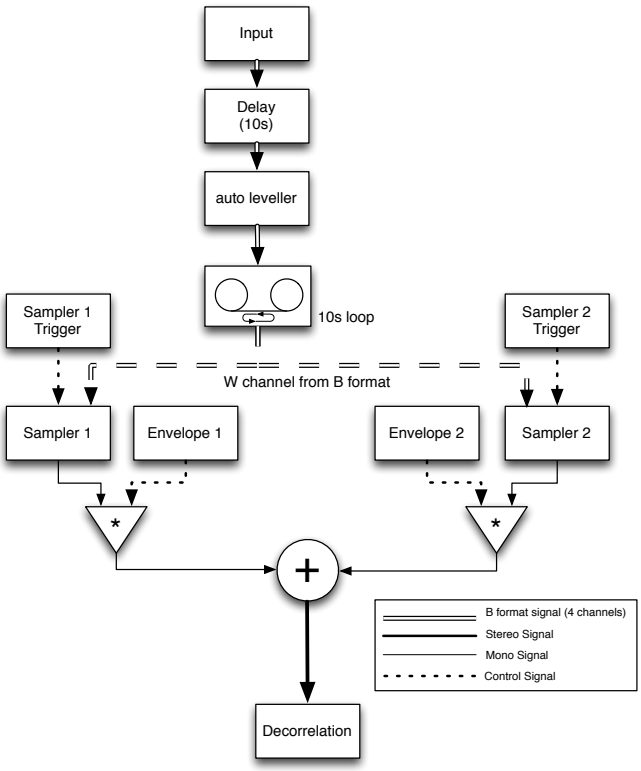


Figure 6.6: The Two Samplers

Chapter 7

And Now For Some Music

7.1 Commentary

And Now For Some Music (2007) is a piece for a single improvising player with miniature microphone and *infra-instruments* (Bowers and Archer, 2005). The system 'listens' to the player on the basis of a very simple musical model that divides sound in to two classes: pitched and noisy.

One layer of the electronics is an immediate extension of the player's gestures, and can therefore be thought of in quasi-instrumental terms. The player's sounds are deconstructed into atoms of pitched and noisy material and reassembled, but in an errant way. Pitched material is drawn out beyond its original duration, and quantised in frequency, to give it the character of an auto-tune process that pushes back.

Meanwhile, the electronics contribute two further layers that are more gesturally removed. Two recirculating textures are constructed from the noisy and pitched materials respectively. New material is transformed and overdubbed into the current texture, whilst short, looping snatches of the textures are periodically written on top at arbitrary points, so that we are left with constantly shifting and mutating recapitulations of prior moments. The articulation of these textures in the final mix is derived from analysis of the player's actions.

In this sense the overall system has both instrumental and performative qualities, and playing it requires attending to each aspect. Given that each gesture made will partially determine the character of the textured materials for some time in to the future, attention needs to balance itself between the

musical present and an informed supposition of what the computer might respond with some seconds later.

The approach taken to designing the electronics has been to try and make creative use of the frailties of current digital audio analysis, rather than to regard them as failures. The goal is not to strive for a brittle modelling of music whose success depends on near-perfect analysis and re-synthesis, but to find pleasure more pragmatically in the spaces between, where analysis is confused by noise, and where re-synthesis has an eerie blend of the organic and machine-like.

Creative use is made, for instance, of the tendency of two different pitch tracking algorithms not to agree with each other in any but the most unambiguous cases. Sometimes small disagreements can contribute to a development of roughness, larger discrepancies to more dramatic changes in the behaviour of the electronics.

7.1.1 The Recording

And Now For Some Music has had three pubic performances: at the University of Edinburgh as part of the *Transformations* concert series (2008); at City University London as part of the Electroacoustic Concert Series (2008); again at the University of Edinburgh, this time as part of the semi-regular event *Grind Sight Open Eye*, supporting Sam Pluta (2009). Of these, only the first was recorded and on that occasion, the performance was defined somewhat by unexpected CPU overload (see Chapter 4). Furthermore, since 2009 the performance patch has been completely re-implemented to account for obsolete Max/MSP objects and to improve longer time-scale behaviours.

The performance presented in the portfolio is a studio recording made at the University of Edinburgh in 2013, in a reasonably large ($\sim$120 m^3), long and narrow, acoustically damped space. This room is, in fact, a teaching laboratory and the session had an informal 'audience' of a small number of students working hard on an imminent submission at the other end of the room.

The performance made use of a single pair of Genelec 1032 loudspeakers, around 1.5 m from the floor and 3.5 m from my playing position. My sound making resources were an 'infra-flute' (see Section 3.4.1.2, p. 96), a manually operated music box that plays hand punched scores, textured surfaces such as speaker grills, and a small local loudspeaker feeding back the electronic

component. The miniature microphone was routed through a small desk, so that I had immediate and continuous access to the preamp gain, and the feedback speaker was also run through the desk so that I could bring it in and out at my discretion. This 'performance' ecology is shown in Figure 7.1.

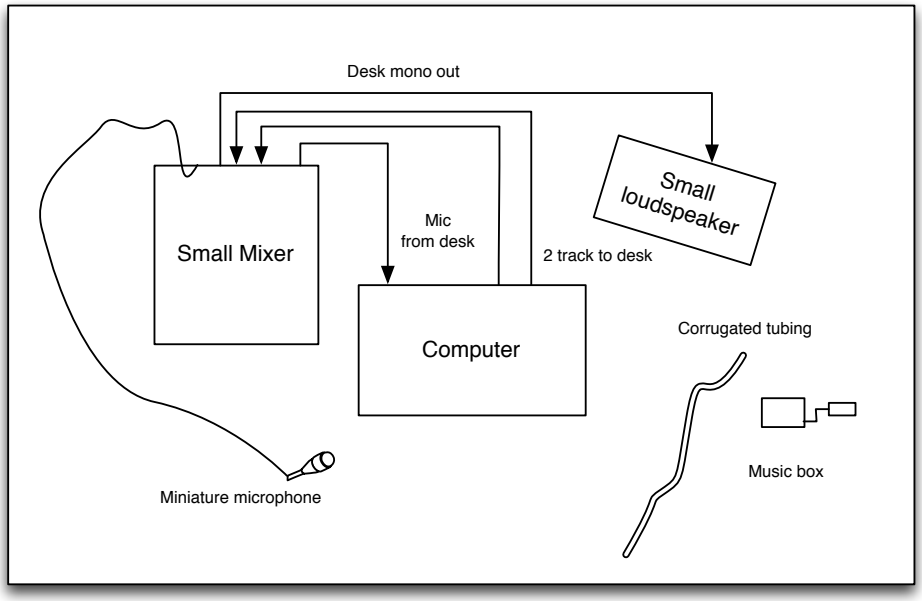


Figure 7.1: A performance ecology for ***And Now For Some Music***

Five takes were performed, and it is the final take that is included in the portfolio. The first three were consciously rehearsal takes where I was happy to stop and try and repeat gestures, and to acclimatise to the system *in situ*. The fourth take was discarded partly on the basis of 'peaking' too early—as the electronics built up to saturation very quickly due to careless initial gain settings—and partly on the basis of my informal audience being clearly audible (struggling with their work) during a quieter section.

As with the recording of ***Danger in the Air*** (see Chapter 6), three stereo stems were recorded to disk using the recording function of my Metric Halo 2882 audio interfaces. These correspond to the outputs of the patch and represent layers of decreasing gestural 'locality'. These were then mixed together with some automation applied to control particularly fierce peaks, a moderate amount of upward compression to bring out details, and some very light diffuse reverb to help bind the tracks together and push them back into the stereo image.

7.1.2 The Performance

The performance can be heard as having three broad sections; the second starting at around 4'36"and the third around 8'32". The first section begins sparsely, with sounds produced by rubbing the miniature microphone (a DPA 4061) on textured surfaces, which produces synthetic sounding tones (for example at 37"). From around 1'10" things become denser, as I produce more gestures, and the computer textures begin to provide accompaniment.

I withdraw around 2'20" and let the computer texture chew on itself and gradually die away until 2'54", when I offer up a series of clicks (2'54", 3'07", 3'17"). Things become sparser and reduce to very soft impulsive material, and I intersperse small gestures from 3'44" made by dragging the microphone down the ribbed surface of the infra-trumpet, which produces more bursts of synthetic tone.

The second section commences with the production of a muffled bass tone, produced by inserting the microphone into the reflex port of the feedback loudspeaker (a Genelec 1029a) and articulating the response using the desk. Another big bass gesture at around 5'10" is finally picked up by the computer which then starts producing a muffled bass line as the tones recirculate, and I accompany with more texturally produced synthetic tones, and augment this with another feedback gesture at 6'10", this time with a richer spectrum.

This gets taken up and recirculated as a tone that has a didgeridoo-like quality when the computer starts to produce a series of pulsing gestures at 6'35". I offer up higher tones on top of this, made by blowing across the top of the infra-flute to produce an unstable sound that flips between its upper partials. A conventionally blown note at 7'26" gets picked up by the re-synthesiser as a very clean sinusoid and almost immediately forms a small chord with itself in one of the textures. The bass drops out, and small pattern repeats itself, gradually dying away.

Whilst this happens, I put in some occasional short tones that are picked up by one of the buffers and ring modulated, producing a soft, gobbling pattern over which I put in occasional notes from the music box. Everything dies away, and a new texture gradually starts to form from music box notes and winding noises, joined by clicks at 10'27", which are my last actions. A soft and unstable texture forms, and at 11'19" the texture with the clicks reemerges pitched down, as it starts to seem like it is running out of energy, I stop proceedings just after a very soft and relatively unaffected snatch of music box.

7.2 Technical Documentation

7.2.1 Quick Start

And Now For Some Music is a piece for solo player with miniature microphone and a selection of pitch making and textured objects (corrugated tubing, music boxes, radios, loudspeakers, mouths, grills, stubble...).

You will need:

- A miniature microphone, such as a DPA 4060/1.
- As many as six, as few as two, loudspeakers for PA.
- An additional small loudspeaker for feedback.
- Objects.
- Preferably a small mixer.

If using six loudspeakers, I recommend having the pair for channels 5/6 upstage, forming the long side of a trapezoid relative to the pair for 3/4, further downstage, but still behind the performer. 5/6 can face backwards. 3/4 should fire towards the audience. 1/2 in this configuration should be near the performer, and can be arranged as a fake dipole, with one facing upstage with its polarity flipped (this helps diffuse the mono 'local' signal into the room somewhat). See Figure 7.2.

If using fewer speakers / output channels, then please yourself. I have, in the past, performed with just two outputs, but through a full diffusion rig (with someone sympathetic on the desk).

In your immediate vicinity should be the small loudspeaker and the mini mixer. Feed the mic through the mixer so that you have direct control of its gain. Interpose the desk via the sound card (sending out a mono mix of outputs 1-6) so that you can bring it up and down (maybe via an aux). If you like, also feed the individual channels to the desk before FOH so that you can mix on stage (can help control dynamics). See (Figure 7.1 above).

Playing:

- The system will attempt to split the microphone input up depending on whether it determines it to be pitched or not (although its threshold for this decision is variable). Pitches will be re-synthesised (poorly) and 'time stretched'. If one gets stuck, you need to give the system a definite onset to move it on by tapping the mic on something.

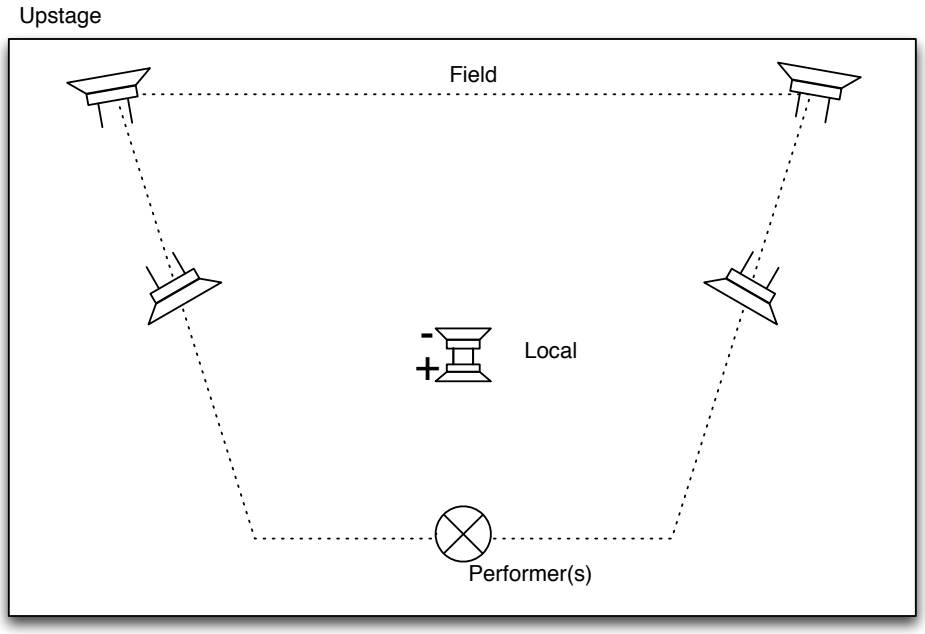


Figure 7.2: Plan of suggested layout when using all six loudspeakers.

- The dynamics are different depending on the balances of input and output levels, so you will probably need to 'play' the desk to an extent.
- The computer aggregates noisy and pitched material separately into separate evolving textures, whose dynamics are derived from your play.
- Interesting textures and tones can emerge through using the small speaker to feed the whole process back on itself. You will definitely need one hand on the desk here to stop it blowing up too much.

7.2.2 Overview

The overall signal flow can be seen in Figure 7.3. The signal is segmented into grains, and fed to an immediate re-synthesis engine, and to two buffers that build textures. The variation of these processes is driven by control signals derived from the incoming audio.

7.2.3 Control Signals

The analysis scheme can be seen in Figure 7.4. Signals are generated from amplitude envelopes, detected pulse rates and the output of pitch trackers.

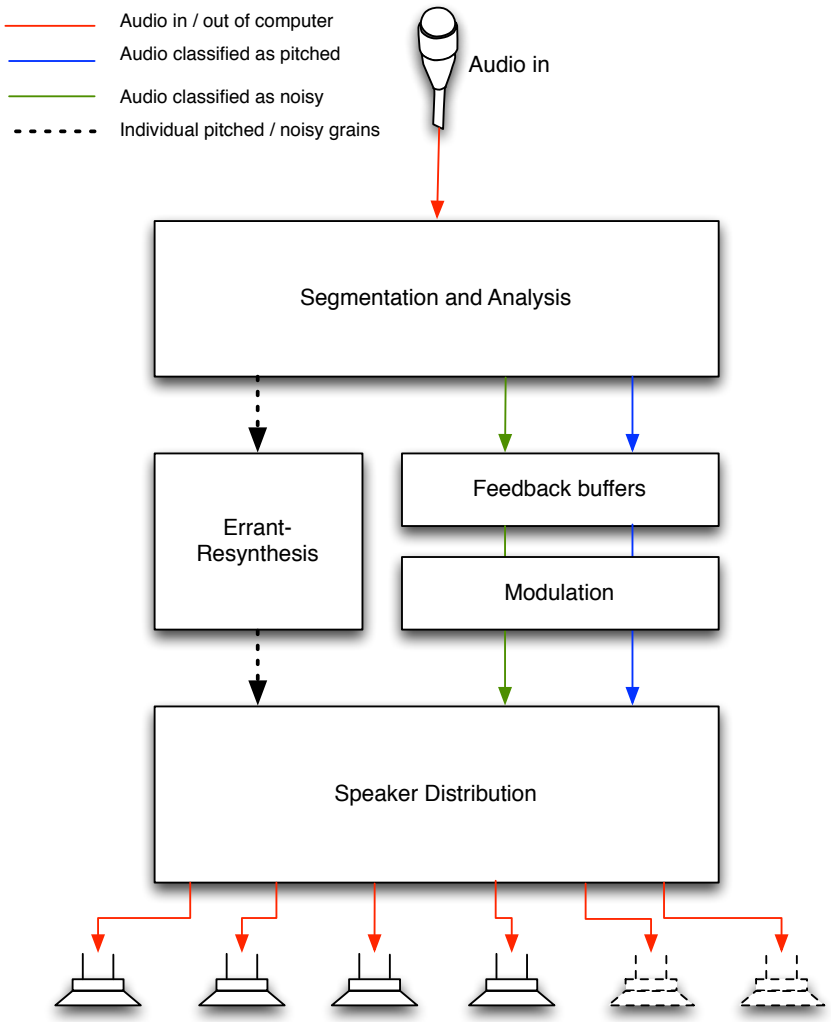


Figure 7.3: Overall signal flow

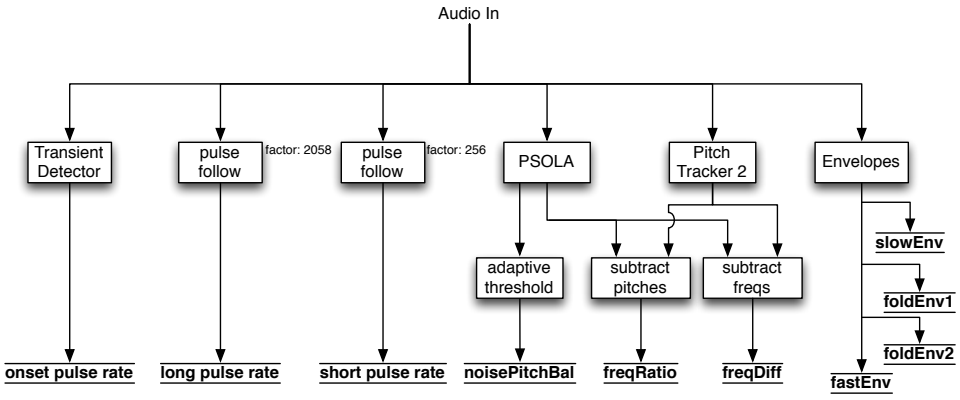


Figure 7.4: Signal analysis and control signals

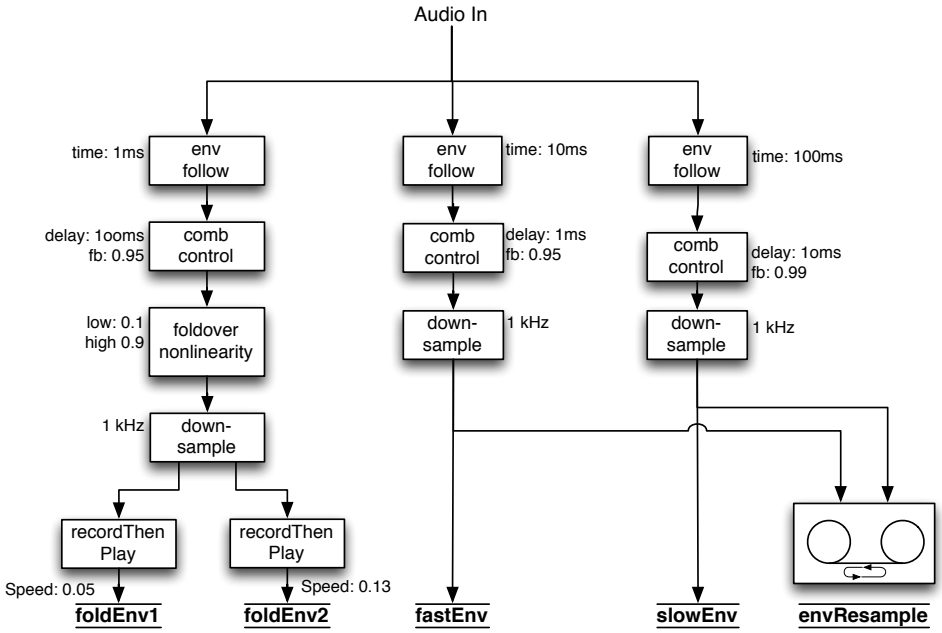


Figure 7.5: Envelopes

The scheme for the envelopes can be seen in Figure 7.5. In addition to fast and slow tracking envelopes (see Figure A.1 in Appendix A, p. 244). In the envelopes **foldEnv1** and **foldEnv2** are mutated, first by a foldover non-linearity (all values in excess of a given range are folded back into that range), and then buffered and read back at different speeds using the record play block, as in Figure 7.6.

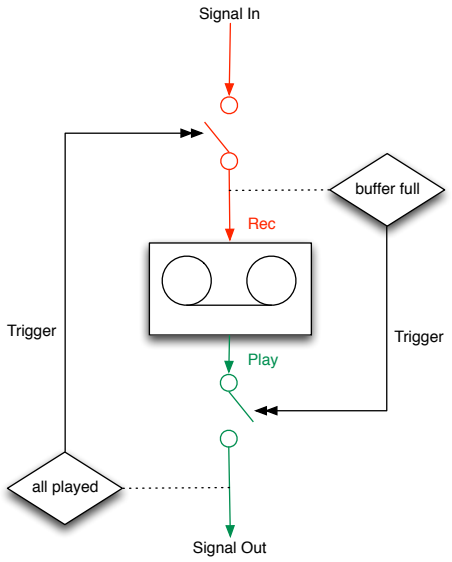


Figure 7.6: Envelope transformation by resampling

Onsets are detected using the scheme described in Figure A.2 (Appendix A, p. 245), and pulse rates are detected using the scheme from Section A.3(p. 244). Two pitch analyses are performed. One of these is based on Pitch Synchronous Overlap Add (PSOLA, see Zölzer, 2002), and is used to segment the input into grains of pitched atoms (two cycles long) or noisy atoms (see Figure 7.7). These are used in the re-synthesis. An additional pitch tracker is used to compare pitch estimates with; its manner of operation does not matter. Differences between the two are recorded in terms of both pitch and frequency.

The threshold used by the PSOLA process to classify pitched / un-pitched material is subjected to adaptation (see Figure 7.8), such that system tries to keep the number of classifications of each equal. This means that response of the system shifts for a player over time, particularly if they are providing a constant amount of one type of material for a period.

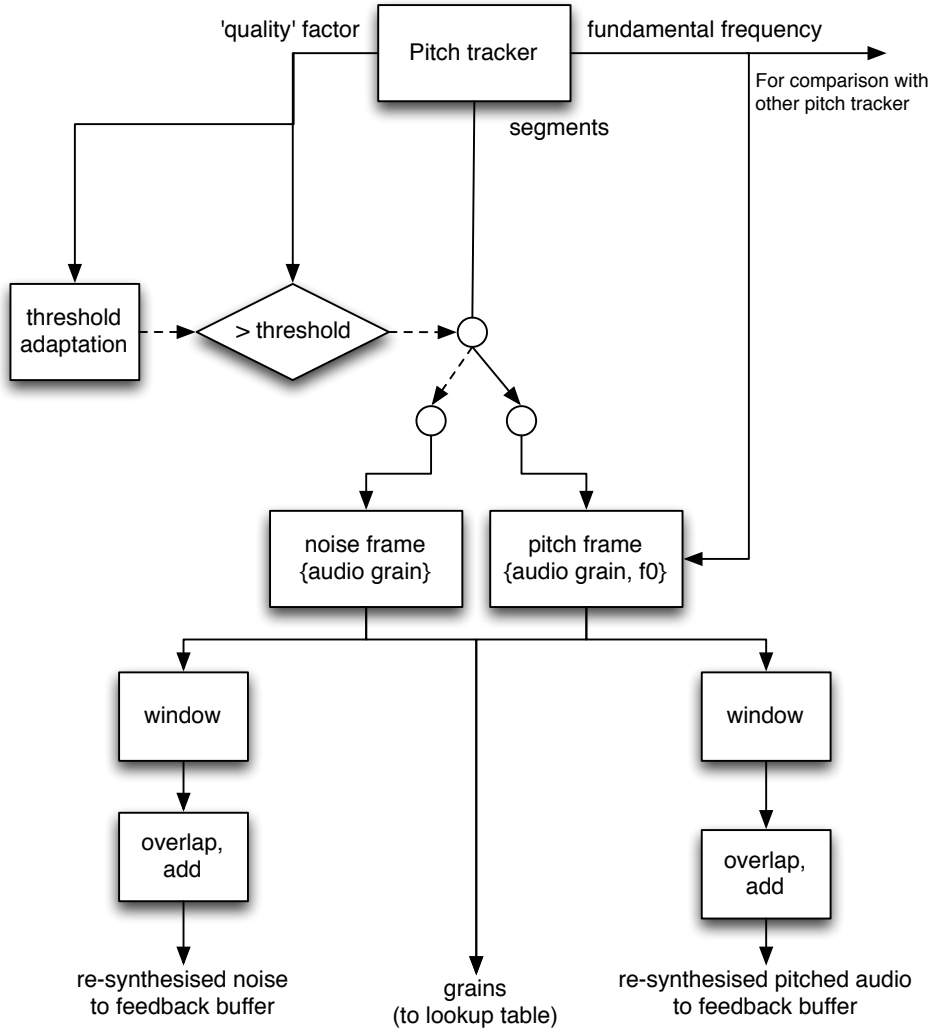


Figure 7.7: PSOLA segmenation

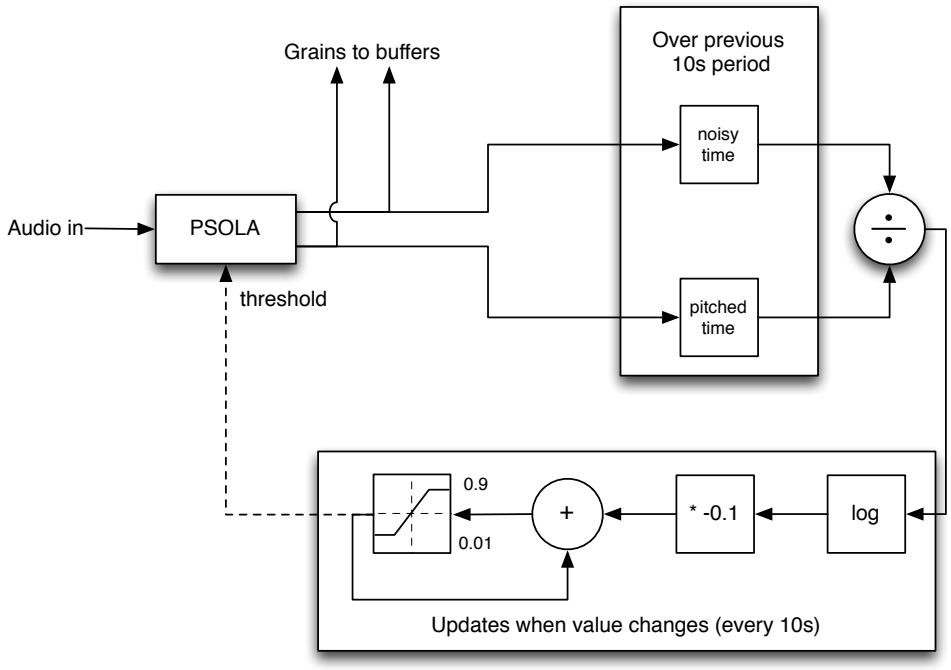


Figure 7.8: Adaptation of PSOLA threshold

7.2.4 Re-synthesis

When the grains are reassembled, they are subject to two transformations. One is two draw out ('time stretch') the synthesis of the pitched material to accentuate its artificial feel, and provide strange hanging notes. The other is to quantise the pitches to intervals Partch's 43-tone scale (rel. 440). See Figure 7.9.

7.2.5 Feedback Buffers

Two textures are generated using overdubbing buffers filled with noisy and pitched material respectively. The general scheme is the same for each buffer, as shown in Figure 7.10. The details of transformation and amplitude modulation differ in each case. Input to the noisy buffer is frequency shifted, for instance, whilst input to the pitched buffer is ring modulated. Playback rates, sample start positions and lengths, panning decisions and the amount of overdub feedback are all driven by the control signals in different combination. Please refer to the code for full details.

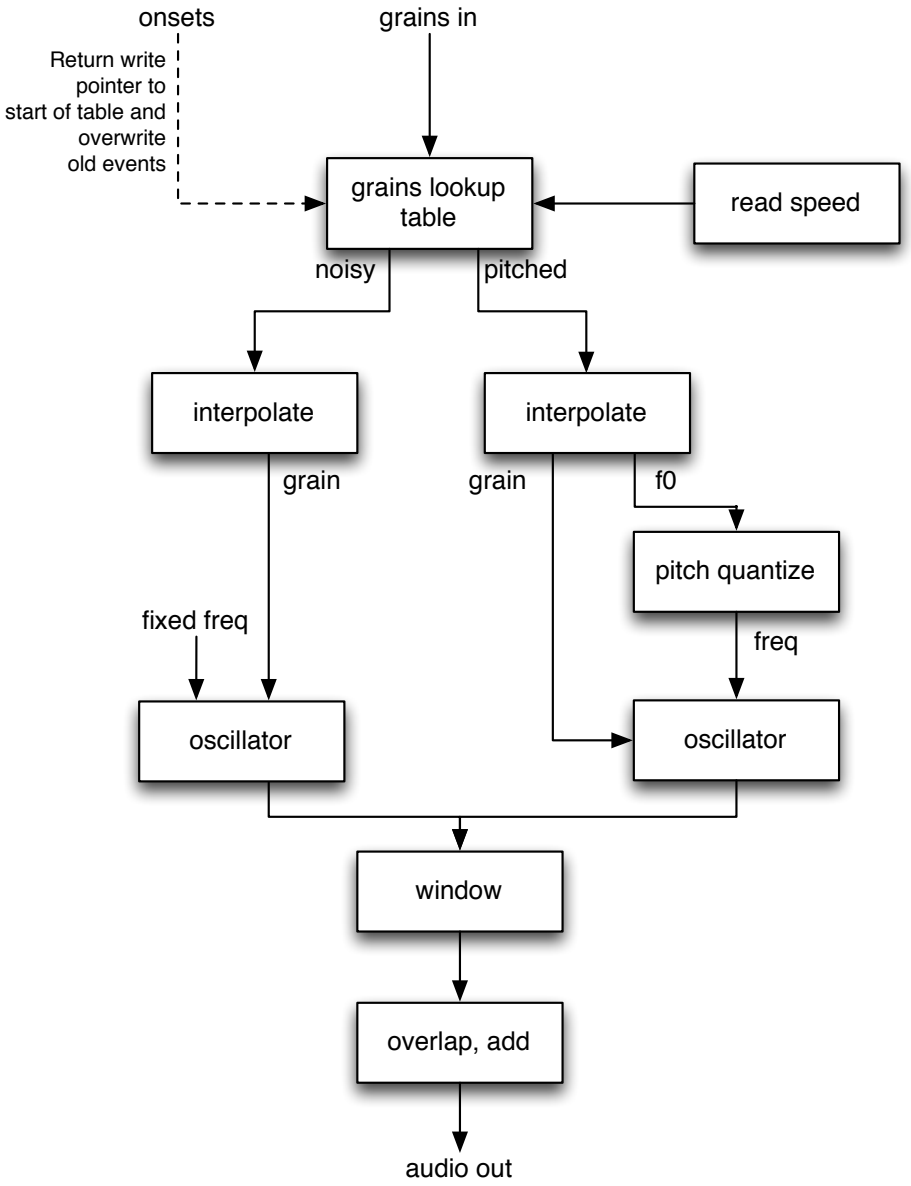


Figure 7.9: Errant re-synthesis

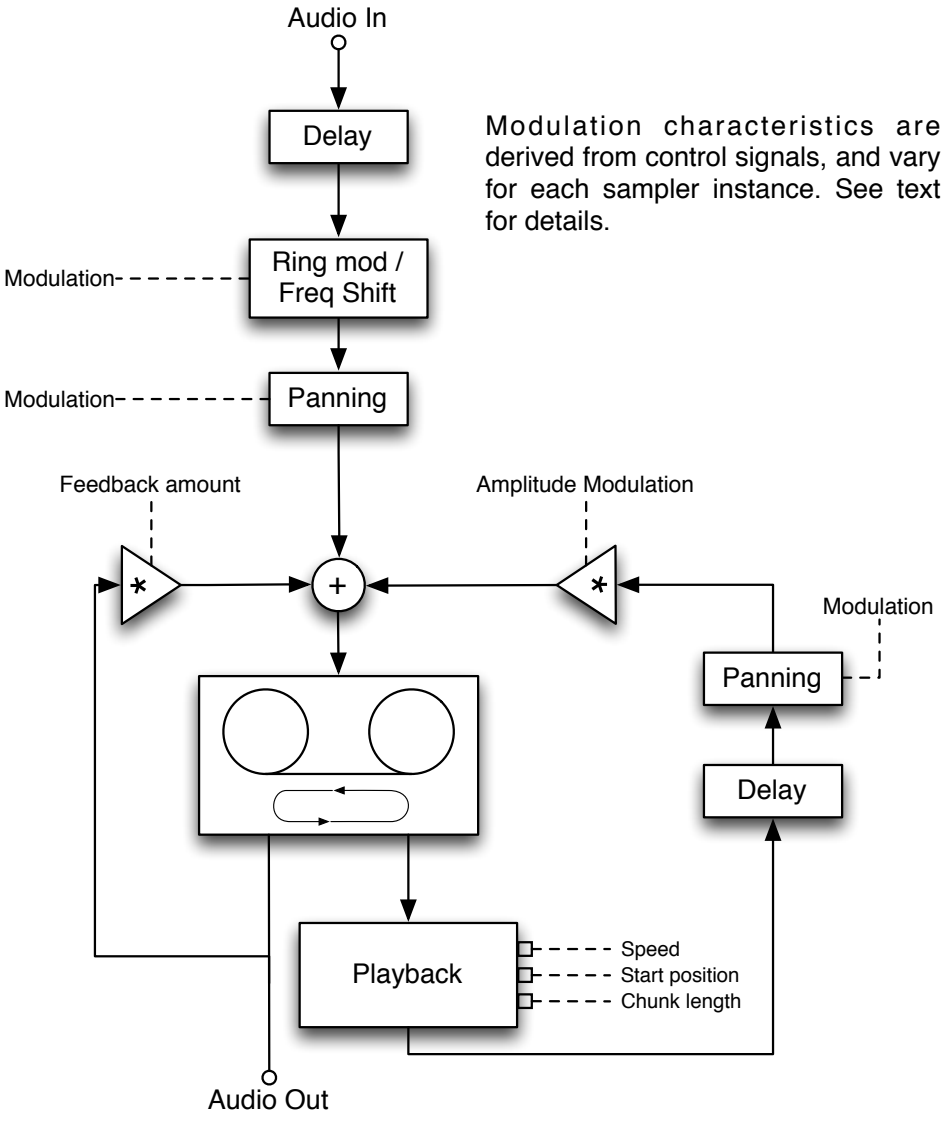


Figure 7.10: Overdubbing Buffer

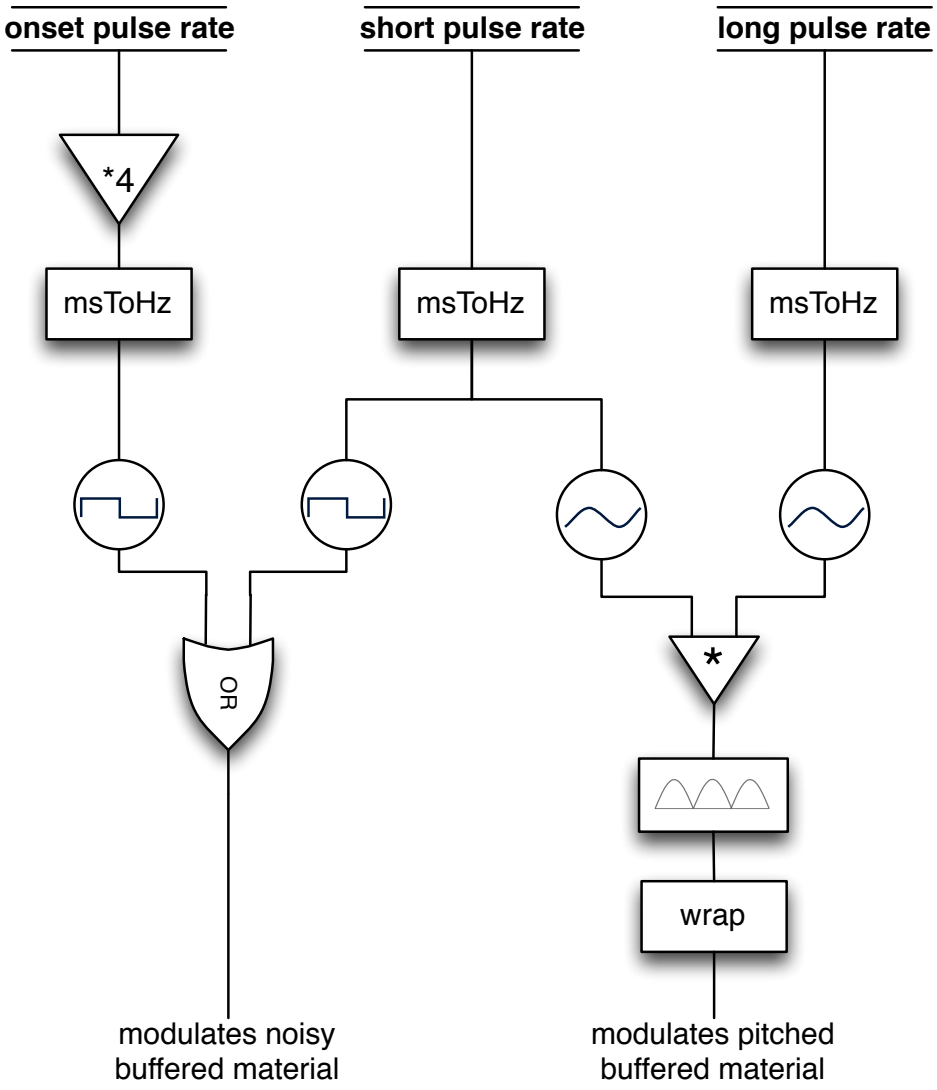


Figure 7.11: Level control of noisy and pitched Buffers

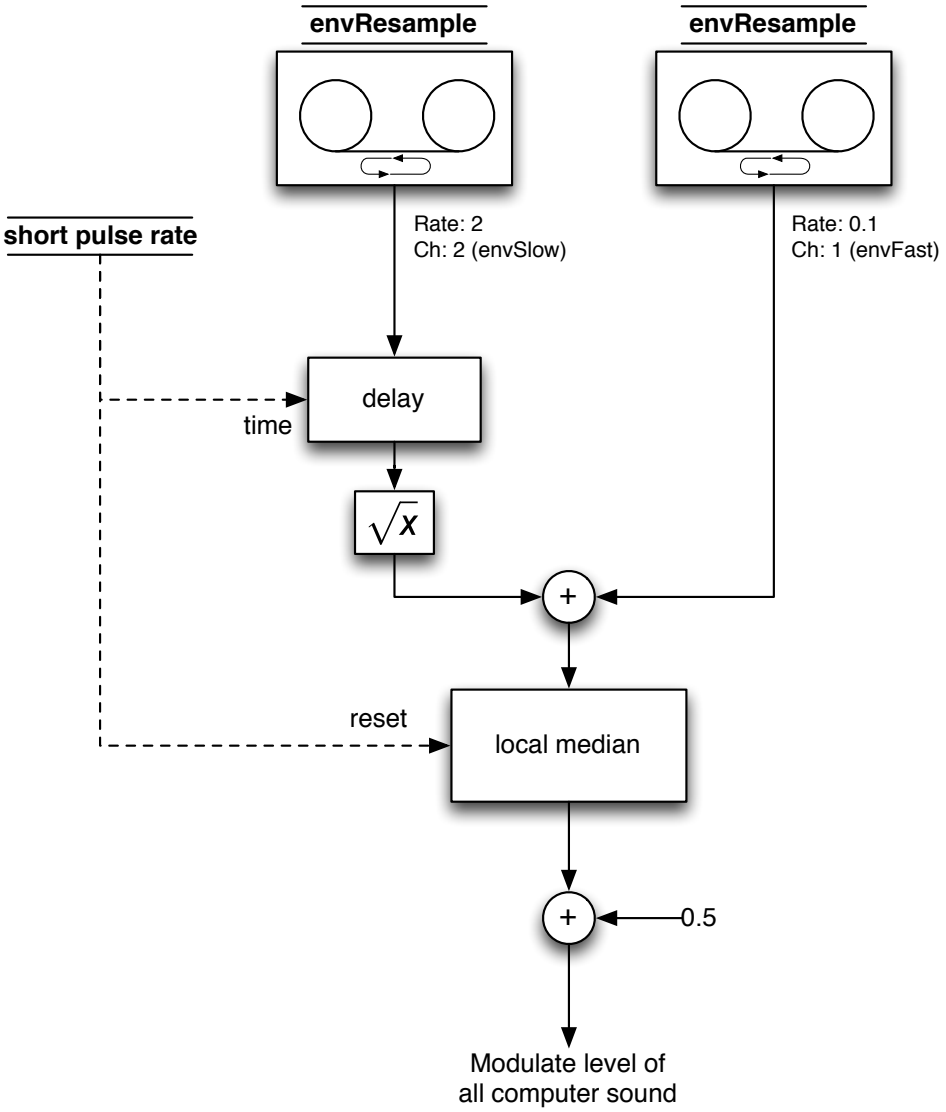


Figure 7.12: Level control of computer voices

The output signals of both buffers are also modulated by control signals, to control their presence / absence from the overall mix. Each buffer's level is modulated separately first (see Figure 7.11), then the overall level of the computer's contribution to the sound is modulated (see Figure 7.12).

Chapter 8

Cardboard Cutout

8.1 Commentary

Cardboard Cutout (2010) is a study for improvisor with bowed cardboard box and electronics (see Section 3.4.1.5, p. 100). It is distinct from the other pieces in the portfolio in that there is a more strongly determinate element to the temporal progression of the electronics part.

The modulation of the various processes at work in the patch is driven, in large part, by a sequencer that moves through a series of pre-defined steps (see Figure 8.3 on p. 202 in the technical documentation below for details of this). The progression of the sequence is still driven by player input, however, so whilst the ordering and certain temporal aspects of the electronic processing are determinate, their precise pacing is adaptive.

This approach was initially taken for purely pragmatic reasons. The piece was originally intended solely as a study in preparation for a duet piece with a *proper* bow player (cello or viol), intended to explore the sonic and dramatic juxtapositions of engineered / found and trained / novice[1]. However, I found that the box had considerably more to offer than anticipated, and so developed the electronic processes as a study in exploring its timbral affordances.

A further motivation for developing a deterministic element to the electronics was to provide a mechanism for the computer part to make more sudden transitions than I had been able to achieve with the purely signal-driven approach of previous pieces so as to convey a stronger sense of structure. A priority for future work on this system is to revisit the sequencing mechanism,

[1]This project has yet to happen (due to both potential collaborators suddenly having children), but is due to start later in 2013.

which is currently coded in a cumbersome and brittle way in order to increase its adaptivity, whilst preserving the ability to provide structural shifts, and to make it considerably less arduous to make changes to the sequences of conditions and timings than is currently the case.

As with ***And Now For Some Music*** (see Chapter 7), the internal processing decomposes incoming sound into two classes. Rather than using a pitch tracker to do this, however, in this case the decomposition is performed on the basis of separating sinusoidal and transient elements, even if they overlap in time. These are then processed separately, with the idea that this offered greater scope for choosing to sooth or exacerbate the intrinsically harsh sound of bowed cardboard.

The piece features less autonomous contribution from the electronics than the previous two. Where there are temporally independent electronic articulations, these function more as an extension of the player's current gesture than as a layer to play upon or with. The system occupies positions at varying points along a continuum of processor-instrument, with only occasional forays in the direction of co-playerhood.

8.1.1 The Recording

Cardboard Cutout has had four public performances: as part of the Dialogues Festival, Inspace, Edinburgh (December 2010); at a *Grind Sight Open Eye* event supporting Han-Earl Park, St. Cecilia's Hall, Edinburgh (February 2011); as part of a festival of local electronic music at the Forest Café, Edinburgh (June 2011); and an informal concert of PhD researcher's work at the University of Edinburgh (December 2011).

The version featured in the portfolio is from the first public performance of the system. This was selected on the basis of being the most successful both musically and technically. Later performances all suffered from less satisfying dynamics from the electronics (as I attempted to replace the programmed sequence with more adaptive behaviour) or poorer recording. The February 2011 performance, for instance, was recorded from the mixing desk and sounds particularly unpleasant and shrill in louder passages, as if the microphone capsule (a Neumann KM 140) was saturating.

The June 2011 performance was not recorded and, in any case, was complicated by a particularly cacophonous laptop crash in the middle. For the December 2011 performance the electronics felt particularly sluggish and the

Instantaneous Complex Frequency processing (see Section 8.2.7) was not working. On stage I managed to compensate somewhat through theatrically shaping the performance by going round the boxes flaps (so making an ABAB kind of form as the larger flaps offer different sounds and affordances to the smaller), but recording itself is somewhat dull.

The included performance, from December 2011, was recorded both straight to disk from Max/MSP (as a single stereo mix) and by a pair of room microphones around 3 metres from the stage (Neumann KM 184s, in an ORTF configuration). The submitted mix is a blend of these two recordings. The room microphones have volume automation applied so that they are pushed back in quieter sections, which otherwise sounded too distant. The two large feedback events are considerably damped using automation on both stems, as they sounded too large in the closer listening circumstances of the studio. A small amount of upward and downward compression is applied to the 'dry' stem in order to control peaks and bring out details. Finally, a small amount of diffuse reverb is used to help blend the stems.

8.1.2 The Performance

The performance can be heard in four distinct sections, as per the programmed sequence (see Figure 8.3, p. 202). The second starts at 3'18", the third at 7'00" and the fourth at 9'55".

The first section is defined by a series of large, drawn out gestures, bowing long strokes on the lid of the box. The sound is processed such that its internal partials are shifted upwards, giving it a slightly animal quality. Accompanying a change to smaller, tighter gestures at 2'00", the direct sound is joined by some background textures from the computer, first made up of transformed snippets of sinusoidal material, then joined at 2'30" by a texture of transient elements. Density increases until around 3'00", when the textures are allowed to die away.

Section 2 starts with all transient material suppressed, and the sinusoidal elements wrestling with an unstable filter bank, allowed to jump around in its search for prominent spectral peaks. A transposed version of the tonal material is also variably present, giving a richer, almost harmonic timbre.

As the filter bank searches for spectral peaks, so there is a greater propensity for the system to go into feedback, which is compensated for by automatic gain controls, and the certainty that the filter will move on in due

course. There are three such events in this section, of varying intensity, at 4'35", 5'19" and 5'49", which then recirculate as part of accompanying textures of tonal material. These events excepted, this section remains spacious and sparse.

The third section is also relatively gesturally sparse, but has a darker more tense feel than Section 2, as a backdrop of drones is provided by causing the filter bank to only update periodically. This means that it holds onto spectral snapshots of particular moments, over which we can hear chirruping gestures of relatively unprocessed box playing, becoming more intense and metallic at 8'38".

Before the start of the final section, there is a short interlude of completely unprocessed box, producing very low frequency tones caused by creating turbulence on a very loosely held lid (so as to maximise the vibrating surface area). The start of Section 4 is heralded by the appearance of a bass drone that stays with us for the remainder of the performance.

We return to similar processing as the opening, with the slightly animal modulation of the box tone. I start by interweaving drawn out bowing with shorter, scratchier gestures. As the computer gradually introduces more of a texture made up of transient components, I give way to only producing the longer notes, and we hear again the sample-hold filter from the previous section. My final gesture is at 11'45", whereupon I allow the computer to play out, first having the texture die away, and leaving just the distorted bass drone from 11'52" to 12'13" at which point I abruptly switch it off.

8.2 Technical Documentation

Cardboard Cutout is a solo piece for player with bowed cardboard box.

You will require a microphone (or a submix of microphones) for the box, and two loudspeakers, as a stereo pair. Normally I use a DPA 4061 miniature omni inside the box, and / or a small diaphragm condenser (e.g. Neumann KM140) near-ish by.

The computer sound can be reinforced with the player's dry signal, although this is not handled in the patch. One thing to try is to use a different, more local speaker for the dry signal, so as to spatially distinguish between player and computer. I like to set up a fake dipole by duplicating the same mono signal, polarity flipping one and sending that to a speaker firing backwards so as to create some bloom.

The piece has some timed elements that are progressed according to a measure of the accumulating energy of the player. These change balance of effects. In broad sweep, the sequence goes from quite dirty at the start, a bit cleaner in the middle, filthy at the end.

So if you're really quiet, it will take longer (and vice versa). There are broadly four sections, you can see which you're in on the indicators.

8.2.1 Overview

An overview of the signal flow can be seen in Figure 8.1. The signal is decomposed in to transient and sinusoidal streams. The transient stream is fed into a granulator, and the sinusoidal stream to a different granulator, but also a filter and, optionally, a module that transforms the signal by manipulation of its instantaneous frequency.

8.2.2 Control Signals

The main control signals in the patch are a series of impulse trains, generated through a series of resetting accumulators (see Figure 8.2). These accumulate at different rates and reset when they hit a value of 1. The rate depends on the time constant τ—how long the accumulator would take to build up to reset for a constant full deflection input. The output is converted to an impulse train that sends a spike each reset. There are six such spike trains using value of τ of 0.5ms, 0.74ms, 40.3ms, 70ms, 115ms, 800ms.

8.2.3 Sequencer

The slower three spike trains (70, 115 and 800ms) are used to drive the sequencer, which provides a determinate sequence of routings and mixing levels through which the performance progresses. The sequence of events is shown in Figure 8.3.

8.2.4 Harmonic Transient Separation

This uses a scheme suggested by Derry Fitzgerald (2010), shown in Figure 8.4. The signal is transformed to the frequency domain by a 4096 point FFT, with an overlap of 4. The magnitude spectrum is then median filtered separately in time (treating each DFT bin as a datum in a independent stream) and frequency (filtering across the DFT bins), and the output of these filters is used to build up different masks that are then used to filter the input frame.

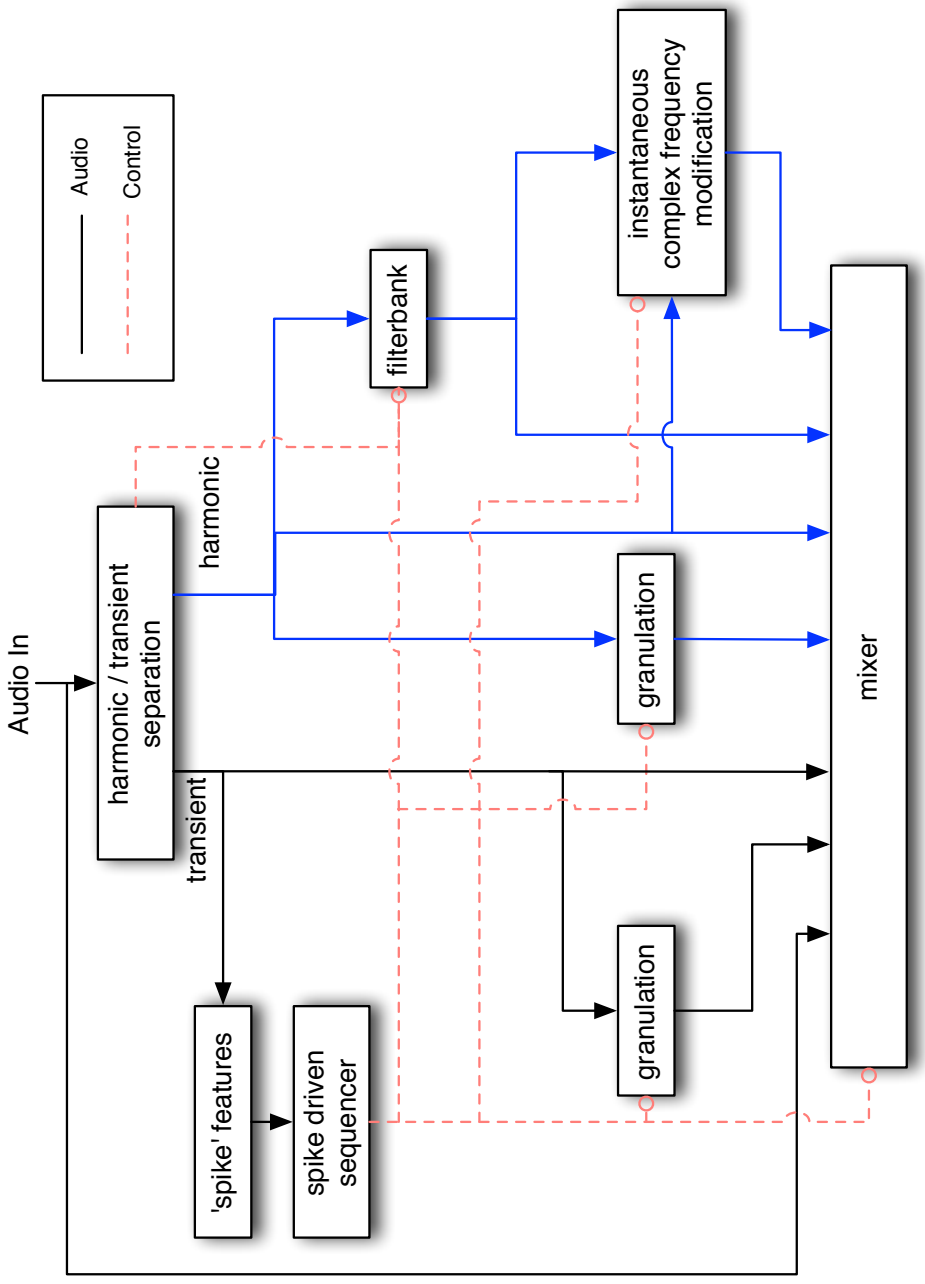


Figure 8.1: Overview of signal flow

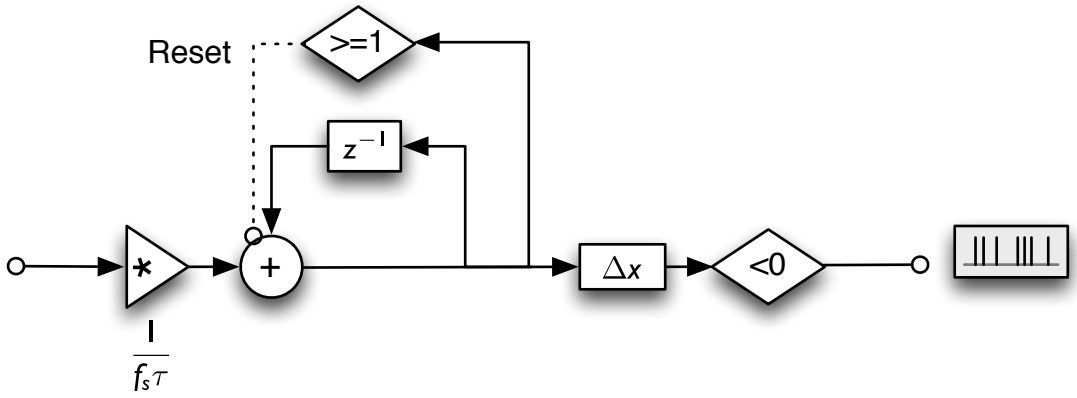


Figure 8.2: Accumulator design

8.2.5 Granulators

There are separate granulators for the transient and harmonic streams, shown in Figures 8.5 and 8.6. The behaviour of the granulators is driven by the shorter τ spike trains (0.5, 0.74 and 40.3ms). The spike trains are converted back to ramp waveforms, that have their rates multiplied or divided to control aspects such as triggering rate, grain length, buffer reading position and transposition.

The harmonic grains are actually subject to two granulations, the second working on the output of the first. This allows the voice to be thickened, and chord-like sounds to emerge (but not too predictably).

8.2.6 Filtering

The data from the spectral analysis is also used to configure a filter bank that can be applied to the harmonic signal (see Figure 8.7). A smoothed and slowly moving estimate of the spectral peaks is formed, and resonant filters placed at the appropriate frequencies and relative amplitudes. A threshold above which to select peaks, and a control to freeze the updating of frequencies can be controlled from the sequencer. The filtered signal can also be overlaid by two symmetrically transposed copies of itself, also controlled by the sequencer.

init	harmonic➡ICF, harmonic -6dB, transients 0dB
§1	*on* 1st **Spike5** transient grains in
	on 5th **Spike5** filter in, detuned 3ct, high threshold
	after 2 of **Spike5** and > 20 **Spike4** *each* **Spike4** ICF shift = rand
	first **Spike4** *after* 5th **Spike5:** transient grains fade out (60") *then* set ICF freq shifts to 0
§2	*on* **Spike6** filter detune 100ct, long decay, low threshold transient grains fade out (30") transients -24B harmonics off
	wait 4" filter fade out (20"), with reducing detune *then* harmonic grains in
§3	*on* **Spike6** filter fade in (60"), short decay, high threshold harmonic grains fade out (40") *then* transients off, open gate for **Spike4**
	each **Spike4** filter increase decay, until threshold *then* freeze / unfreeze filter updates (*each* **Spike4)** filter ➡ ICF filter detune ↠ 30ct (30") *then* start 12" pulse
	on each 12" pulse fade ICF in and out (6" each way) increase ICF mutations
	after 11 pulses (132") stop pulses
§4	ICF 0dB
	wait 1" *then* noise in, noisy grains in, filter detune 300ct, long decay harmonic ➡ ICF, filter !➡ ICF modulate ICF all pass shift ±π over 10" decrease ICF magnitude scaling over 60" ICF minimum phase shift 2 ↠ π (30") filter fade out (10")
	wait 40" noise grains fade in (25")
	wait 120" filter fade in (12") *then* increase ICF all pass scaling over 40"

Figure 8.3: The programmed, spike-driven sequence

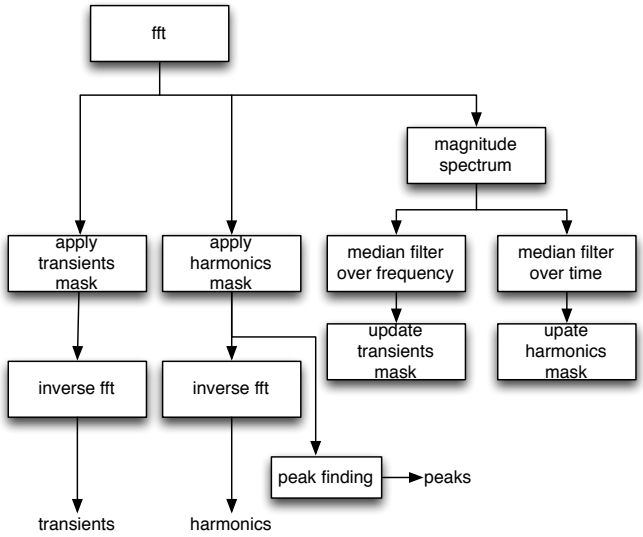


Figure 8.4: Harmonic-transient separation

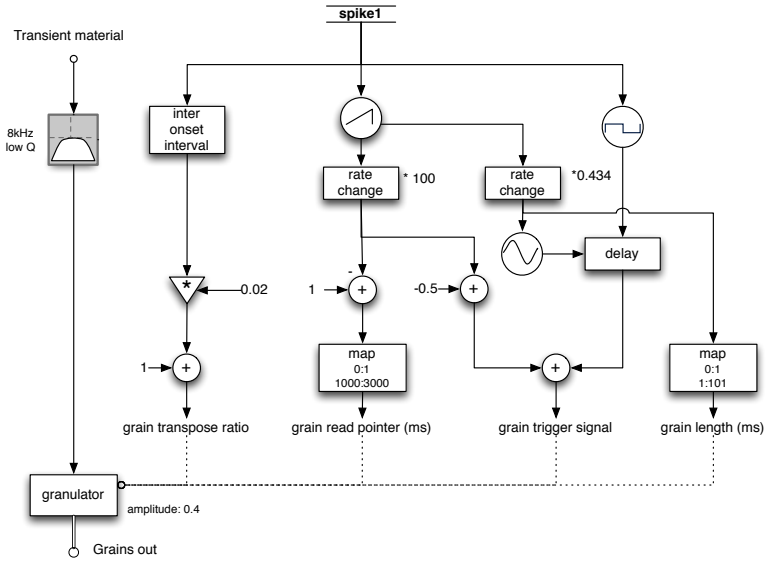


Figure 8.5: Control of transient grains

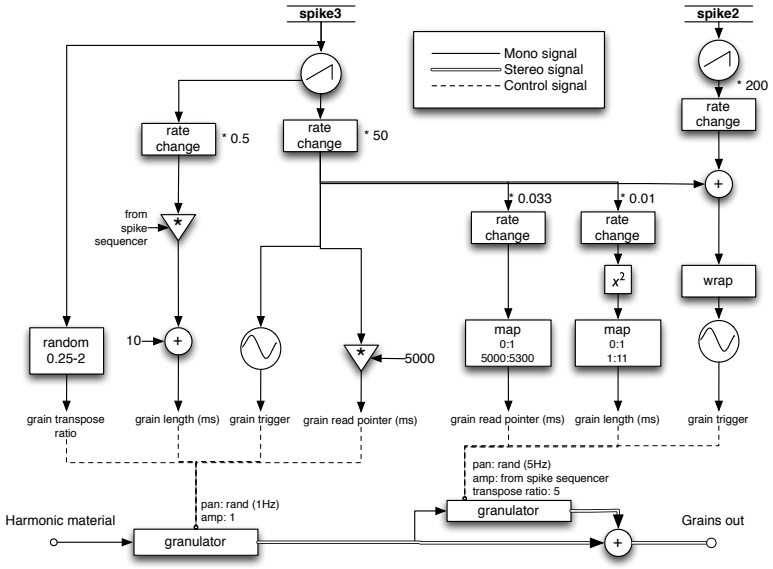


Figure 8.6: Control of harmonic grains

8.2.7 Instantaneous Complex Frequency Processing

This module implements a scheme proposed by Kaniewska (2010), as shown in Figure 8.8. The signal is decomposed into 'minimum phase' and 'all pass' components, each of which is a complex-valued signal. One can then manipulate the amplitude-slope and instantaneous frequency of these components independently. The effects are slightly unpredictable but broadly the all pass frequency seems related to the partials of a sound, so these can be stretched or shifted. The minimum phase frequency seems to affect, more subtly, the formant structure of a sound. Changes in the amplitude-slope of the minimum-phase component serve to change the dynamic range of the signal to give quite glitchy, dirty effects.

I will provide a walk through of the algorithm, as it is not completely self-evident from Kaniewska's paper, the maths is slightly involved, and there's a possibility my interpretation is faulty:

The incoming signal is made complex using a Hilbert transform, which produces copy of its input shifted by $\frac{\pi}{2}$ radians:

$$u[n] = x[n] + j\mathscr{H}(x[n])$$

Where $\mathscr{H}$ denotes the Hilbert transform and $j = \sqrt{-1}$. The magnitude of $u[n]$ is taken to be the magnitude of the minimum phase component, on the

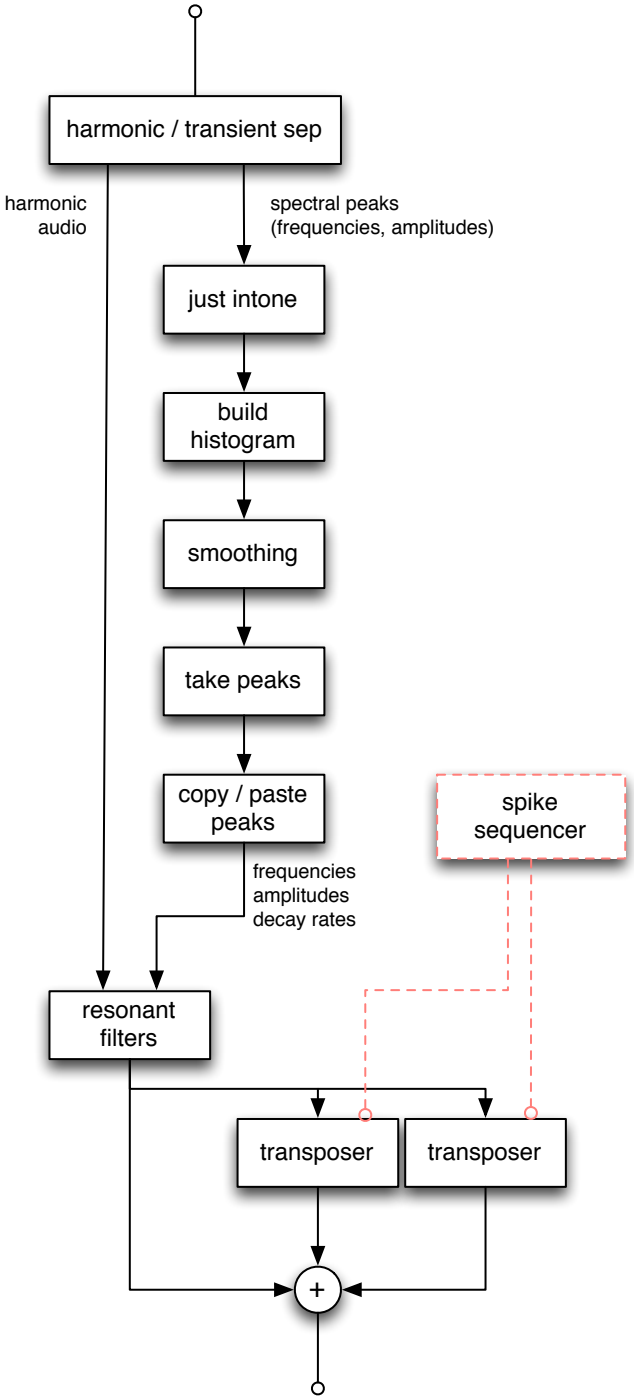


Figure 8.7: Filtering of harmonic signal

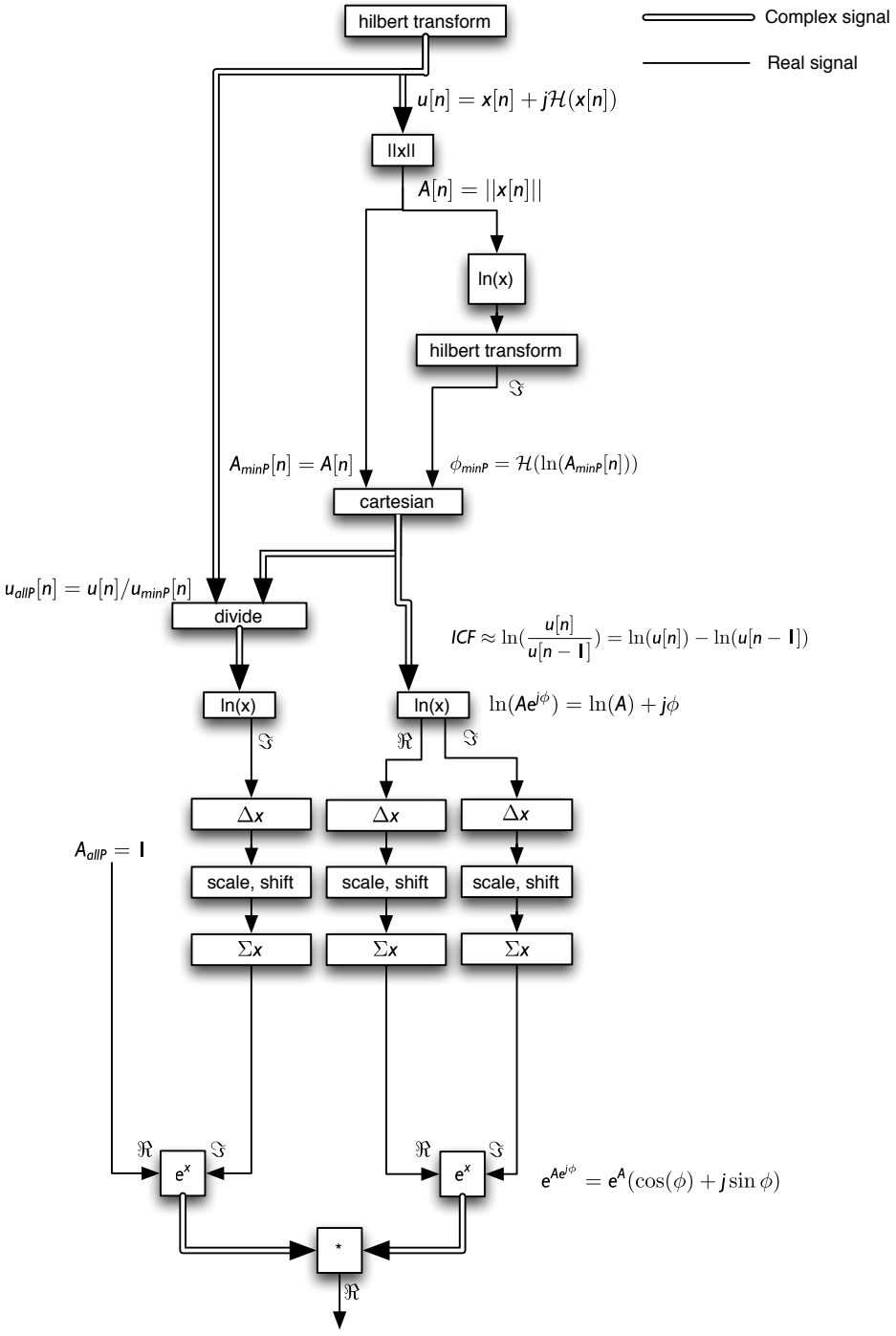


Figure 8.8: Modification of instantaneous complex frequency

basis that the all pass component always has a magnitude of 1.

$$A_{mp}[n] = A[n] = ||u[n]||$$

The phase of the minimum phase signal is related, by definition, to its amplitude

$$\phi_{mp}[n] = \mathscr{H}(\ln(A_{mp}[n]))$$

Which gives us both parts of our complex minimum phase signal

$$u_{mp}[n] = A_{mp}[n](\cos(\phi_{mp}[n]) + j\sin(\phi_{mp}[n]))$$

The all pass component can then be found by dividing our original complex signal by the minimum phase part

$$u_{ap}[n] = \frac{u[n]}{u_m p[n]}$$

The instantaneous complex frequency (ICF) is defined as

$$s[n] = \frac{d}{dt}\ln(u[n])$$

Bearing in mind that the complex logarithm takes the form

$$\log(z[n]) = \log(|z[n]|) + \angle z[n]$$

The imaginary part of $s[n]$ will be the normal instantaneous frequency, viz. the first derivative of the phase angle of our signal. The real part is the slope of the signal's log-amplitude.

The ICF is calculated separately for the all pass and minimum phase components, as the first difference of their complex logs. They are then subjected to whatever scaling and shifting is desired, and re-accumulated. The complex log is reversed with the complex exponential:

$$z[n] = e^{\log(|z[n]|)}(\cos(\angle z[n]) + j\sin(\angle z[n]))$$

The whole signal is then reassembled by multiplying together the reconstructed minimum phase and all pass components, and returning the real part.

Chapter 9

Exchange. Value

9.1 Commentary

Exchange. Value(2012) is a piece for three laptoppists using the popular Ableton Live software. It was written for the trio of Jules Rawlinson (JR), Dave Murray-Rust (DMR) and I, who have been playing together for some years.

The piece is distinct from the others in the portfolio in a number of ways. First, it employs no live sound input as an intrinsic part of its operation. Second, rather than constituting a territory around which a mode of practice is explored, ***Exchange. Value*** interposes itself upon the techn_e and social relations of an established practice. In this sense, it can be regarded as a very particular musical proposition addressed to my co-players, particular ideas about how we could expand our range of interactions.

A further distinction from the rest of the portfolio, that follows from this, is that the electronics for this piece don't produce sound, but take it away. The primary signal processing at work is the targeted muting of players, based on analyses of their action (via MIDI events) and sound, and its relation to the other players. Each participant runs a Max For Live patch in their Ableton Session that performs these analyses, and will periodically mute the outputs of that player. This muting can happen at different rates, with different musical effects: fast chopping, slower articulations, and prolonged withdrawals.

This approach is a somewhat bombastic tactic devised to respond to the tendency of our laptop improvisations sometimes to form uniformly dense, continuous streams of activity. Computers afford each player producing many streams of sound without prolonged effort, so the piece is one possible way of

providing a counterbalancing tendency, such that more space might open up and our thicker moments become more effective.

Each player takes a stream of audio from each of the others, as has been our practice for some time. This allows a degree of continuity in sound world, and also enables a pleasing ambiguity of agency as sounds are passed around. In this case it is also used as a basis for driving the behaviour of the system. Beyond this cross coupling, and the use of the Max For Live patch, the choice of technology is a free matter for participants. The aim here was to impose on existing techniques and preferences as little as possible; each of us has a distinct relationship with our controllers and software, and this is something I wish to preserve.

9.1.1 The Recording

Exchange. Value has yet to be performed in public, as such. An earlier performance by the same trio, at the Bongo Club, Edinburgh, supporting Ma and Newt (May 2012), used prototypical elements from the eventual system, but only at points and as part of a much longer set (around 35 minutes).

The performance in the portfolio is a studio recording made at the University of Edinburgh in 2013. Stereo stems from each player were recorded straight to disk through my Metric Halo 2882's recording console; the signals from the co-players were passed using ADAT connections that we were using in any case to sample and effect each other's audio.

A shot of our respective setups can be seen in Figure 9.1. On the right is DMR's, using two assignable controllers and a set of pads. At the top is JR's, with a three dimensional Space Navigator mouse, an assignable controller and a big scrub wheel. Mine is on the right, using a simple MIDI keyboard with some assignable controls and a miniature microphone (DPA 4061). The recording is mixed as three overlapping stereo fields, positioned to the left (me), centre (DMR) and right (JR). The balance to be struck here was between making apparent some movement between players and preserving the spatial articulation of participants' streams.

This was the second recording session the group had for this piece. At the first, I had not been happy with any of the takes, primarily because I felt that the electronics were still not responding quite as I would like. The take included is the second and final of the session (after which we went on to play 'normally' for a while). I specified a nominal length for the performance in

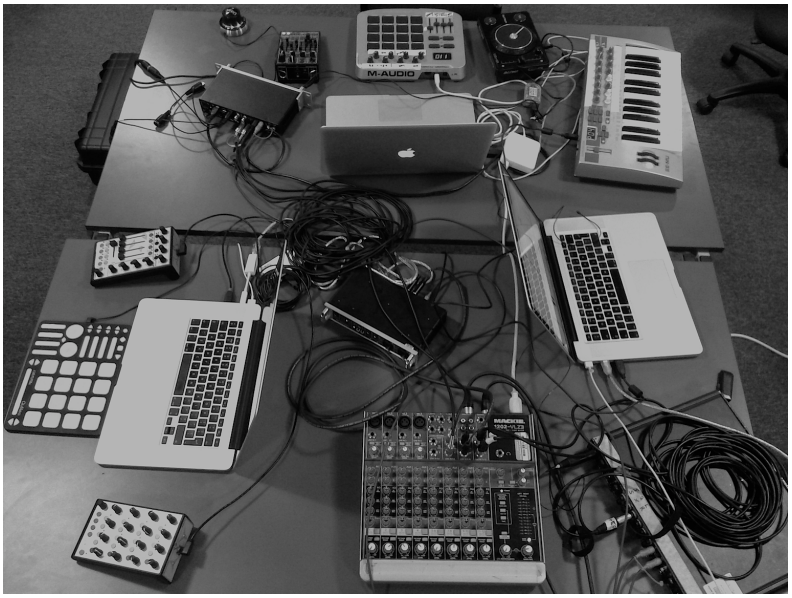


Figure 9.1: The trio's setups for ***Exchange. Value.***

advance. Our first take worked technically, but was somewhat sluggish and tentative as we were still warming up and getting a feel for the duration.

In the final mix some automation was applied to stems in the interests of clarity, and reducing the impact of a couple of audio 'burps' by players. There is some downward compression on each stem, and a gentle reverb was used to help tie them together.

9.1.2 The Performance

The performance can be divided into five sections, with rough boundaries at 3'05", 5'57", 9'37", and 12'15". The first section starts with short gestures, initiated with a bass-pulse loop from me and impulses from DMR. The operation of the muting starts to become apparent at 41", breaking up what might more normally have been a continuous flow. Things become more constant again at 1'16" with a continuous buzz from me, broken bursts from JR and reverberant whistles from DMR.

JR's dirty texture comes to the fore at 2'09", and snatches of Motown from me are immediately picked up and processed with a long reverb by DMR (2'15"). Further bursts of this sample emerge unmolested whilst DMR produces wet, drawn out tones.

At the start of Section 2, (3'05") JR's texture dies away, and there is a choppy burst of sample (me), joined by a very brief surge of vocoded-something (DMR). Bursts of sample are joined by JR scratching on his scrub wheel (3'15"), which forms a thematic in this section. DMR joins in with bursts of a very short, high feedback delay. We are all muted in and out, so there is a great deal of space until a denser moment at 3'45", again at 3'57", and a burst of protracted digital squelch from DMR at 4'27". After another brief interlude of chops, this digital noise reappears as a dense texture from 4'52" before disintegrating into fast mutes at 5'06". We are left with its tail as a continuant from 5'12", which is punctuated by muted patterns of other reverb-tail like sounds.

Section 3 opens with a sequence of dirty bass thuds from DMR alongside some more scrubbing from JR. The scrubbing drops out just as I drop a slowed down vocal sample (Scooby Doo, 'I've never seen footprints like those before') and DMR's chops explode into a distorted siren, then becoming a deep bass noise with higher drone. As this vanishes at 7'00" there is a duet of scrubbing and Scooby Doo. DMR remains quiet until 7'42", when he introduces a wandering series of pitches. I supply some reverberant high-pass impacts at 8'28". JR brings in the scrubbing again at 8'42" as DMR's tones turn to choppy bursts of low pass noise that end the section on top of some sampled tones from me.

The fourth section opens with me repeatedly triggering a sample to form a little riff. JR brings in a high texture, and DMR is sampling me whilst being muted. Both he and JR bring in textures built off my sample at 10'42", whilst I keep things steady until being fragmented by mutes at 10'54". A bed of this choppy sample and an aggregated texture from the other two form the rest of this section, with the choppy sample eventually becoming just a deep rumble.

The final section is opened with a sudden high speed gesture from JR at 12'15", followed by some more that DMR then samples and offers back at 13'20". They join together in a watery texture at 13'48" and I reappear with some spoken material at 13'59". This material turns to the subject of white noise from 14'08" to 14'21", and JR is able to respond with a burst of noise, which turns to a chopped impulsive sequence, as DMR continues with the watery grains. DMR has the last word at 15'12" with a short flourish of muted noisy material.

9.2 Technical Documentation

9.2.1 Quick Start

Exchange. Value is a piece for three interconnected laptop players using Ableton Live. Using data about players' actions it makes interventions in the form of muting outputs and changing Live's tempo.

You need:

- Computers, with at least 6 audio ins and outs each.
- Some speakers (as many as six).
- What ever MIDI controllers you normally use (up to four can currently be used with the patch).
- Ableton Live >= 8.2 with MaxForLive (Max >= 6.0.7)
- The M4l devices `otg.exchange.value.master` and `otg.exchange.value.coplayer`.

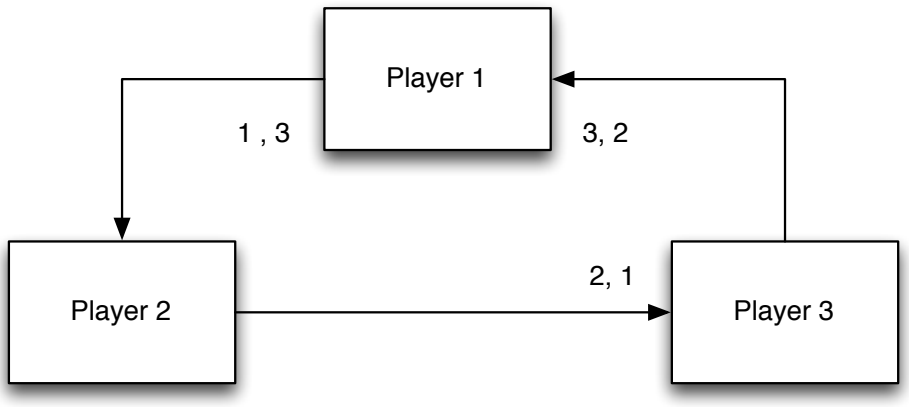


Figure 9.2: The ADAT triangle flow of audio. Numbers denote which players' audio is being sent down which line.

Setup:

- Each player needs a feed from the other two. Typically we do this with a triangle of ADAT connections, with one player on 1-2, another on 3-4, and so on (see Figure 9.2) . This means setting up so that players

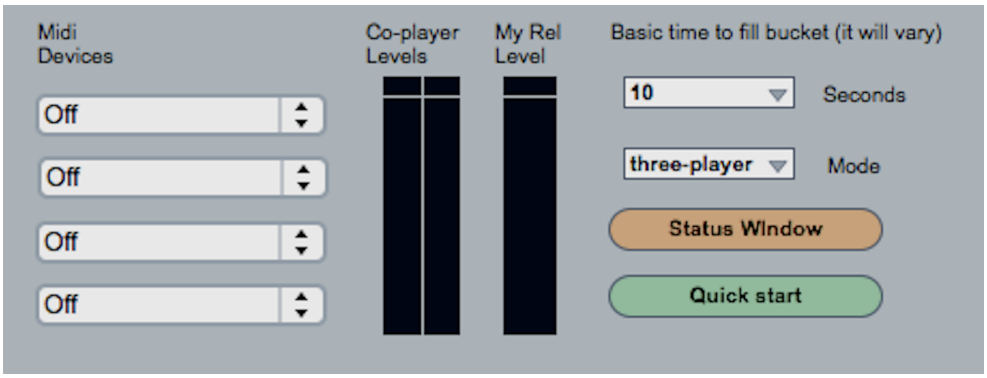


Figure 9.3: The master device's interface

are forwarding their neighbour's audio to their other neighbour, but also ensuring that you don't accidentally set up a feedback loop (purposefully is fine).

- It is better to all come out of computers separately into a mixer, as this allows more flexible routing and alignment. Given that the system is sensitive to relative levels, take care to align levels on the desk so that people aren't made to thrash their digital levels in order to be heard. Live has a tone generator in the prefs for this purpose. Alignment of a -20dBfs sine wave at 0dBVU is one way to proceed.

- Set up two channels in your Live set that monitor your co-players' incoming signals (i.e. switch to 'in'. You probably don't want to hear them directly, so mute (or don't)).

- Place an instance of `otg.exchange.value.coplayer` in each of these. Set one to 'control 1', the other to 'control 2'. This should persist between sessions.

- Place an instance of `otg.exchange.value.master` (see Figure 9.3) on your master channel (or route everything to a track and put it there; or only selectively route things. It's up to you). You should see a little floating status window in the bottom left corner.

- Set mode to three-player (one-player is just for practising)

On the status window, shown in Figure 9.4 is a small dial to the left. This is your bucket. It fills when you make sound. You can adjust how quickly in the 'basic time to fill bucket' section of the master patch.

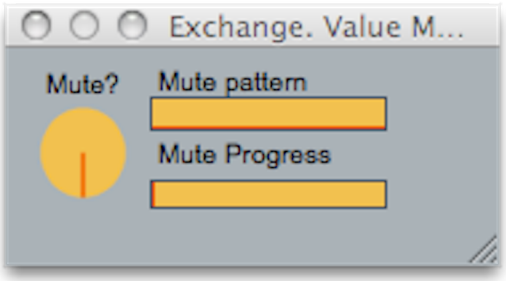


Figure 9.4: The status window

When the bucket fills, muting kicks in for a duration based on how long it took to fill. The pattern of mutes is determined by the onsets your co-players produce. The speed with which switching happens is determined by how many audio onsets you produce relative to the number of MIDI events you have made (but not straightforwardly mapped, so don't try and game it).

If your patterns of audio-midi activity remain the same for long periods, you get muted more quickly.

The tempo is set based on your MIDI input. It may well go to some strange places; you can set it yourself in the normal way and the tracker will use that as a new ref. I like to have tap tempo enabled too, so that I can quickly get to a new pacing.

9.2.2 Overview

The audio processing for ***Exchange. Value*** is comparatively simple, as shown in Figure 9.5. Audio is simply gated according to the outcome of analysis on one's own and one's co-players' audio signals, as well as one's MIDI events.

9.2.3 Analysis

For each signal, an RMS average level is returned, and onsets are tracked. The RMS is calculated as

$$x_{rms}[n] = \sqrt{\frac{\sum_{i=0}^{N-1} x^2[n]}{N}}$$

Where N is the number of samples in the analysis window, in this case 100ms long (so 4410 samples at 44.1kHz).

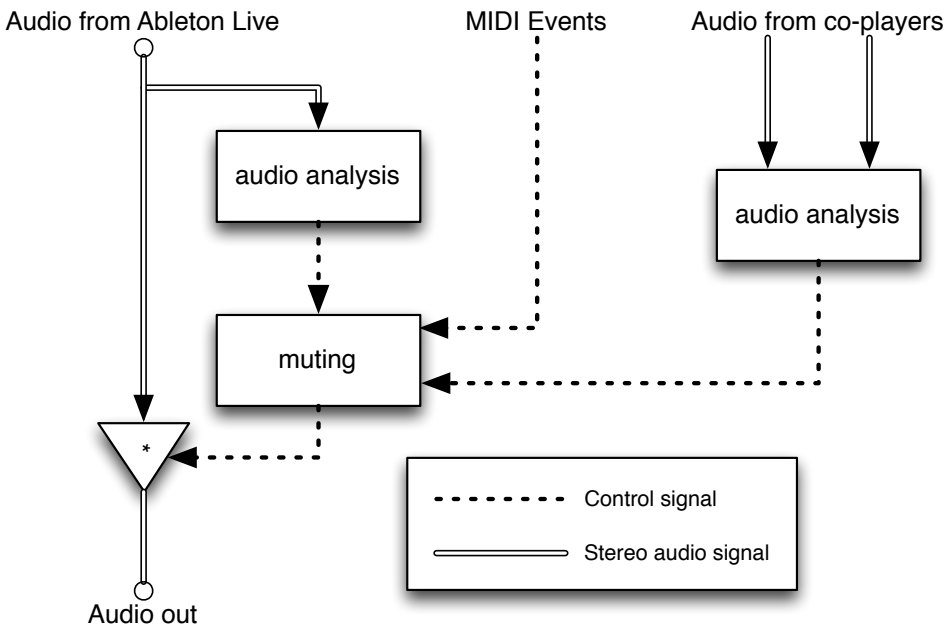


Figure 9.5: Overview of signal flow

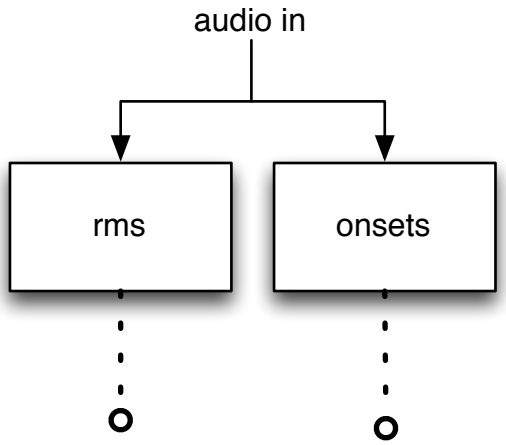


Figure 9.6: Audio analysis

Figure 9.7: Onset detector

Onset detection uses the scheme shown in Figure 9.7. Part of this process uses the transient detection method already used in other pieces (see Figure A.2), but it is augmented here, for slightly tidier behaviour. I have adapted a scheme suggested by Gifford and Brown (2008) which was in turn inspired by a technique known as Empirical Mode Decomposition (EMD).

EMD is a data-driven process that attempts to decompose a signal into a set of monotonic components so as to afford highly accurate time-frequency analysis of non-stationary signals (Huang et al., 1998). It works by searching for, and successfully removing, candidate lower frequency trends from a signal, based on the data in the signal itself. For each component it performs a cycle where first the minima and maxima of the signal are found, and two curves are generated that interpolate between them. A local median is derived from the difference between these upper and lower envelopes, which is then subtracted from the input signal. This repeats until the local median is flat, and the resulting signal is returned as a component.

Gifford and Brown suggest using just the first stage of this process to construct a useful function for onset detection, which they call a 'noise' function, as the first component extracted by EMD (being the fastest moving) is normally composed of the noise in a signal. I perform this stage using Doug Van Nort and Kyle McDonald's EMD Max/MSP object[1].

9.2.4 Muting

The player's level is used to fill a 'bucket'. When the bucket fills, a cycle of muting takes place. The bucket is implemented using a resetting accumulator, shown in Figure 9.8. The accumulator outputs impulsive events that are used to derive timing information, and a ramp waveform so players can see how full their bucket is.

[1] http://code.google.com/p/realtime-emd/

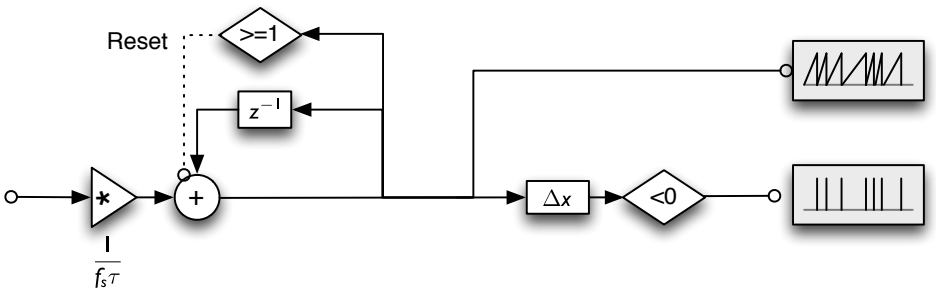


Figure 9.8: Bucket accumulator

What happens when a muting cycle takes place is based on an assessment of the relationship between a player's levels of physical activity relative to the amount of audio activity. This is taken in terms of a ratio of audio to MIDI onsets accumulated over a time window

$$\text{ratio} = \frac{\Sigma O_{audio}}{\Sigma O_{audio} + \Sigma O_{midi}}$$

This ratio, taken at the time a bucket fills, determines which of three possible rates muting takes place at: fast (semi-quaver-ish), medium (crotchet-ish), slow (whole-bars). The mapping is not linear with respect to the audio midi ratio, as this would encourage gaming the patch. Rather, lots of relative MIDI activity[2] will yield medium muting, so that short bursts of rapidly changing textures might emerge. Little MIDI activity will yield fast muting, so the computer takes over the role of articulator, in a sense. The slow mutes happen when there is a middle of the road audio-MIDI relationship on the (quite groundless assumption) that this is the most boring kind of material. A future embellishment will be to make this more sophisticated by nesting time scales within a cycle in more complex ways.

The *patterning* of the muting, is determined by the onset patterns tracked from the co-players. Groups of eight successive onsets are aggregated, and these are combined in a Joseph Schillinger-inspired way (Absil, 2011). Given two lists of onset times, $\mathbf{o}_a$ and $\mathbf{o}_b$, the resulting pattern is their union

$$\mathbf{o}_{new} = \mathbf{o}_a \bigcup \mathbf{o}_b$$

[2]MIDI activity is derived from Note On events, and CC changes. De-bouncing is used to filter out rapid repetitions of CCs within a single gesture.

The resulting list then forms the template pattern for muting, which is constantly updated. Different muting speeds simply entail reading through this table at different rates. The idea here is that the muting patterns could, in principle, bring forth musical congruences that emerge through their interaction.

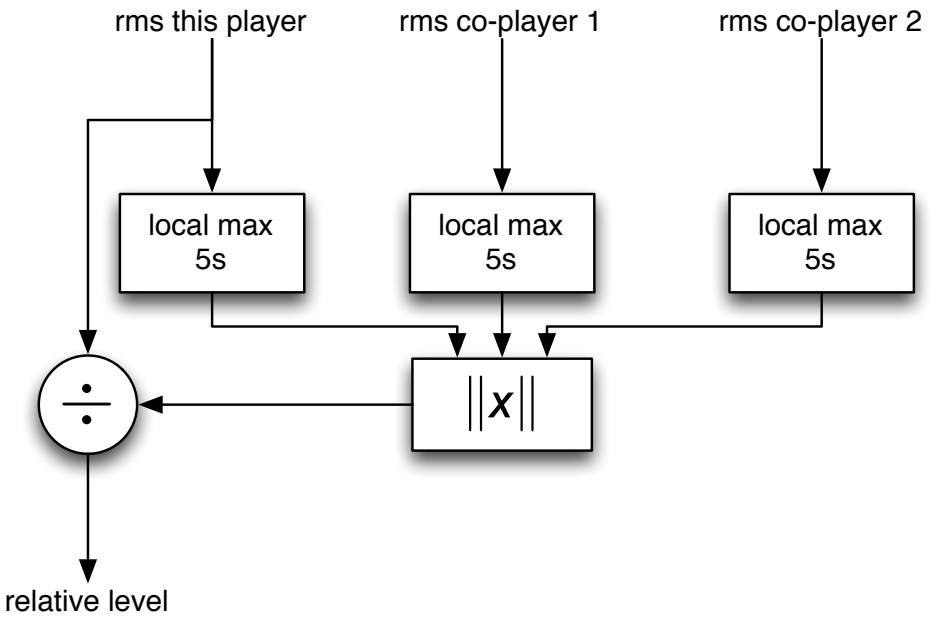


Figure 9.9: Relative level calculation

Two factors affect how quickly a bucket fills, all else being equal. One of these is the player's level relative to the overall level of the trio, taken as a fraction of the overall maximum level in the preceding 5s window (see Figure fig:ev:rel). The overall level is calculated as

$$x_{rel}[n] = \frac{x[n]}{\sqrt{x^2_{max,1} + x^2_{max,2} + x^2_{max,3}}}$$

The other factor is based on analysis of audio and MIDI onsets. The ratio is subject to further analysis by measurement of its standard deviation over a sliding 25s window, calculated as

$$\sigma[n] = \sqrt{\frac{1}{N-1} \frac{\sum_{i=0}^{N-1} x^2[i] - (\sum_{i=0}^{N-1} x[i])^2}{N}}$$

This tracks the amount of variety the player is bringing to proceedings. If this falls below a threshold, then the filling rate of the bucket is affected proportionally.

9.2.5 Tempo Adaptation

A further use of the MIDI activity is to adapt the tempo of Ableton Live. This is a response to the inadequacy of either having to synchronise to a master clock, or have no sync at all. The hope is that it can form the basis for a closer physical connection to the software, as it encourages timely physical action. I have used a simple scheme as outlined by Brian Pardo (2005). Onsets arriving within a certain fraction of a clock tick are used to update an average measure that, in turn, updates the rate of the clock.

I have implemented this so that the user is not locked out of Live's tempo control (as happens with some forms of mapping with Max For Live). The code uses Live's current tempo as a basis, so the user can always override, or tap in their own tempo.

Chapter 10

Spectral Dweller

10.1 Commentary

Spectral Dweller (2012-) is for two players with room tone and electronics. The piece was put together for Martin Parker (MP, flugelhorn) and I (mouth and miniature microphone) in response to a piece of MP's called *Spectral Tourist* (2003, see Parker, 2007). A poetic motivation here was to contrast tourism and dwelling as different ways of inhabiting, and to try and develop a spectral relationship with a place that grew out of the players' playing through it over time.

The electronic component centres around an idea of co-action: if the players are deemed to be playing together, then the computer constructs a fusion of their input signals with delayed sound from the room. Episodes of separateness are treated separately, and may occasionally be heard (at a considerable delay) as faint whispers.

The computer also has two more autonomous sound making means. One is through a warped analysis-resynthesis of the players' fused streams, the other through bursts of highly compressed room-tone or echoes of previous material.

The current state of this project is such that its status as processor-instrument-coplayer is less ambivalent than it will become with further work. The fused sound functions straightforwardly like a processor, as it stands, as its space of possible responses to players' action does not yet offer the breadth, non-linearity or surprise that would afford instrumental playfulness. The behaviour of autonomous voices, on the other hand, provides co-player behaviour, but again I envisage making this more flexible and responsive to nuance in such a way that it can take on some instrumental character as well.

The bulk of this future work will lie in experimenting further with the way that the sounds fuse and trying to make fuller use of analysis of the co-action (or not) of the performers.

Figure 10.1: The recording space for ***Spectral Dweller***

10.1.1 The Recording

At the time of writing, ***Spectral Dweller*** has had a single public performance at Generator, Dundee (December 2012). Whilst this performance was perfectly adequate, and successfully recorded, I elected to record a new version for two reasons. The first is that the Dundee performance was quite short (just under five minutes). This was for the simple, if mundane, reason that the performance space was incredibly cold (an uninsulated industrial unit in the depths of Scottish winter!) and by the time I started the audience had already been seated for almost an hour. I felt that they were becoming restive

so decided to keep things brief. Second, I had added some new behaviours to the piece since the Dundee performance that I wished to document.

The recording in the portfolio is a studio recording made at the University of Edinburgh in 2013 in an old painting studio that is large ($\sim$200 m^3) and reverberant (see Figure 10.1). I connected my miniature microphone (a DPA 4061) through a small mixer before the soundcard, so that I had immediate control over the preamp gain and could use the equaliser. MP had a pair of DPA 4060s on his flugelhorn, one on the bell, one near the valves, of which he sent me a submix. We used six loudspeakers, in the configuration suggested in the technical documentation below, so that the more gesturally remote computer sounds were more distant and reflected diffusely throughout the space.

As well as the computer elements, the direct signals can be heard in the recording as distinct voices, as the fused signal can not yet stand up for itself against the other elements. Three separate stems were recorded from the patch, corresponding to the loudspeaker feeds shown in Figure 10.3, as well as recording the inputs from the room microphones, In total, then, the mix comprises five mono and two stereo stems.

The submitted version is the second of three takes. This take was selected on the basis of exhibiting the greatest variety of dynamics and textures. In the first take, we were somewhat tentative, and our occasional surprise and disorientation at the computer voices was apparent. In the final take, we were tired but also somewhat rushed.

A certain amount of volume automation was applied in mixing. In particular, the fused voice sometimes seemed to meander unhelpfully, so was pushed back somewhat and compensated for by bringing forward the room microphones and direct signals. Upward and downward compression was applied to all stems separately to bring out detail and control peaks, and a equalisation was applied, especially to tame higher frequency build up, and to control sub-bass rumble. A small amount of diffuse reverb was used to help gel the stems.

10.1.2 The Performance

The overall performance is very still, and constitutes a single territory with punctuations, rather than clearly identifiable sections. Throughout, MP and I broadly try to mirror and synchronise our playing, with occasional exceptions. Our material falls into broad categories of impulses (as at the very

start), wheezy tones (∼50”), clearer tones (2’16”). Much of the time clear, gliding tones can be heard, which form something of a surface on which the performance sits. These are from tracking filters that are used to decompose the players’ and room’s sound and form part of the re-synthesis, wandering somewhat as the filters struggle to keep up with or make sense of the action.

Moments of punctuation come about mostly from the computer’s recycling of room tone. The largest of these is at around 4’18”, as a prolonged section of quick, short loops follows a pronounced impact.

Other, briefer, punctuation comes from the warped resynthesis, such as a brief burst of static at 45”. This is followed by MP and I performing a prolonged, distorted broken-downward glissando, and a series of impulsive material. The large impulses at 1’09”, 1’17” and 1’19” are moments of synchronisation where the combined sound suddenly opens up. The first appreciable interjection of room tone can be heard at 1’52”, following two short static bursts, whereupon we enter a period of more sustained, synchronised tones, until 3’23”.

Some space opens up at this point, and we return to more impulsive material in short bursts, joined by computer glissandi and static at 3’43”. The large impact at 4’18” is brought in by a small crescendo, in which sustained glissandi are brought out of the computer by continuous, toneless blowing from MP and I, which we continue after the impact until 4’31”.

Drawn out tones at 4’45” are followed by another volley of looped room tone, which MP confects with belching horn notes, and we come together into an impact at 4’53”, followed by silence.

A couple of short moans from me at 5’09”, and brief notes by MP are replied to with another series of bursts of room noise, and a synchronised combination of a wheezy tone from MP and some impulses from me provide a responding moment at 5’21”. From 5’27” to 6’07” MP sustains a single tone, and I come in and out in a strangled croak at more or less the same pitch, which brings with it articulations from the computer, ending in a distorted broken up texture.

A short interlude of quiet is interrupted by a burst of noisy room tone, and MP and I start producing short pulses, occasionally colliding, on a bed of wandering tone and static, which gives way around 6’47” whilst we continue the pulses. My pulses become more voiced, and the wandering tone makes a more muted reappearance at 7’03”, briefly pushed out of the way by pulses of room tone at 7’17” and 7’26”. It stays softly present but more broken up

as I withdraw, leaving MP continuing his soft pulses. After three room tone impacts at 7'52", I reenter briefly with impacts as MP shifts into a sucking texture, on the verge of tone-hood, until a fully fledged note at 7'54" signals my exit, and MP finishes off with a creaking, constipated gesture.

10.2 Technical Documentation

10.2.1 Quick Start

Spectral Dweller is intended for two players, interacting with the tone of the space they are playing in. There is a one player mode, but this is intended for rehearsal (meaning I haven't paid as much attention to it as the rest).

You will need

- Microphones for each player. You could use multiple microphones and sub-mix on the way in.
- Microphones for the room, 1 or 2 relatively sensitive condensers. Two is better. Put them somewhere interesting, distant enough from a speaker to get plenty of air in there.
- Loudspeakers. At least two. Preferably six.

The piece was devised for flugelhorn and voice, around a sound world of hisses and crackles. However, it need not (nor should) be limited exclusively to this.

Arrange the loudspeakers at will, although I imagine the following, as illustrated in Figure 10.2. Speakers 1 and 2 project the most gesturally 'local' sound, so should be near the performers. There is only a mono channel here, but one side is polarity flipped. This is because I like to use one speaker firing backwards, one forwards for a sort of fake dipole. Channels 3–4 and 5–6 are more diffuse, with 5–6 having the most diffuse material. If you have four speakers to devote to this, try a sort of trapezoid, with 5–6 upstage and possibly firing backwards. 3–4 should be toed in, further downstage and arranged like a normal stereo pair (but still upstage of the performers).

The piece behaves differently when both performers are playing together. Indeed, if you want any gesturally local sound from the patch, this is what must happen. It will attempt to cross synthesise both players with the recorded sound of the room. When the players don't play together, then the sound is sent elsewhere for further processing.

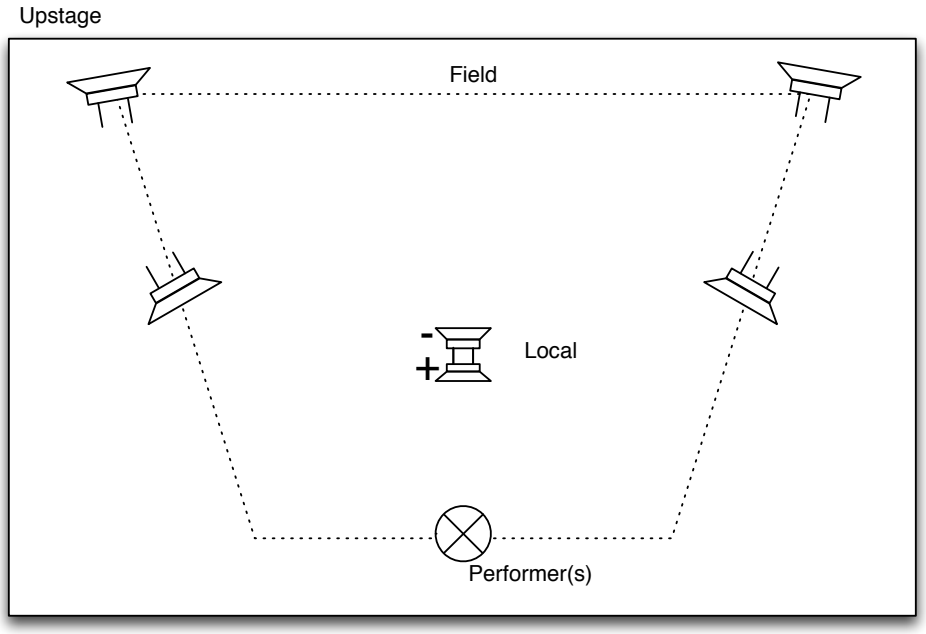


Figure 10.2: Plan of possible loudspeaker layout

There will be interjections from the computer that are related to the pacing of the players' action. Play around these.

10.2.2 Overview

Figure 10.3 gives an overview of the signal flow. There are three inputs, one from each player and a recording of 'room tone' (really, whatever is happening in the room at any given moment). The computer produces four streams of sound: a reconstructed blend of both players and the room tone; a 'warped' reconstruction of the players; a treatment of sampled sounds from the players when they were not playing together; and sampled bursts of previous sounds from the room.

The input signals are all sent to a filter bank, where the room-human synthesis takes place. Audio from moments of un-togetherness is sent to sample memory, **whispers**, and room tone also gets stored, in **roomBursts**. The levels of the warped re-synthesis and the two samplers are then modulated using control signals before the outputs.

The control signals in ***SpectralDweller*** are somewhat more dispersed than with the other portfolio pieces, where they are mostly derived directly

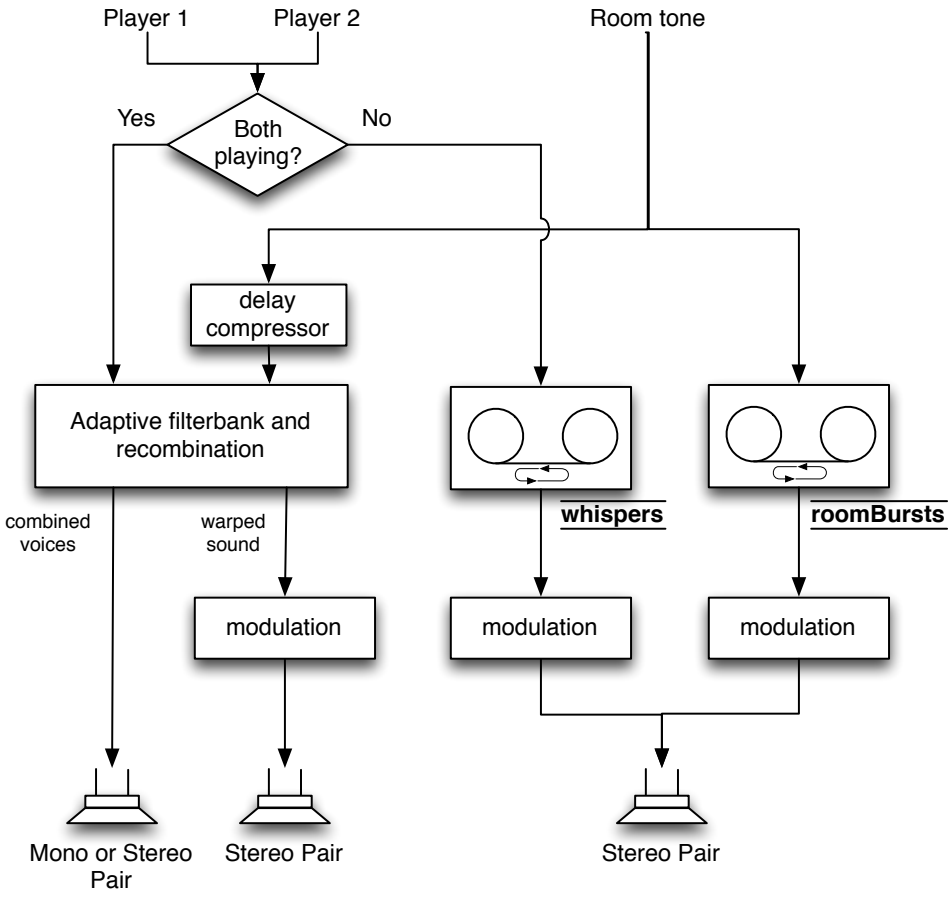


Figure 10.3: Plan of possible loudspeaker layout

from the input. In this case, only one is derived directly from the input, **interOnset**, and the rest are formed after the filter bank.

10.2.3 Togetherness

A simple system is used to decide whether or not both players are playing, as shown in Figure 10.4. Envelopes of the players' signals (see Section A.1 for details of the envelope follower design) are thresholded, such that there is a 0 below the threshold a 1 above it. Simple boolean operators then allow us to control the appropriate switches for both players (AND: audio to filter) and one, but not both (XOR: audio to sample buffer).

The time between 1s from the AND gate—that is the time between episodes of togetherness—is recorded into the control signal, **interOnset**.

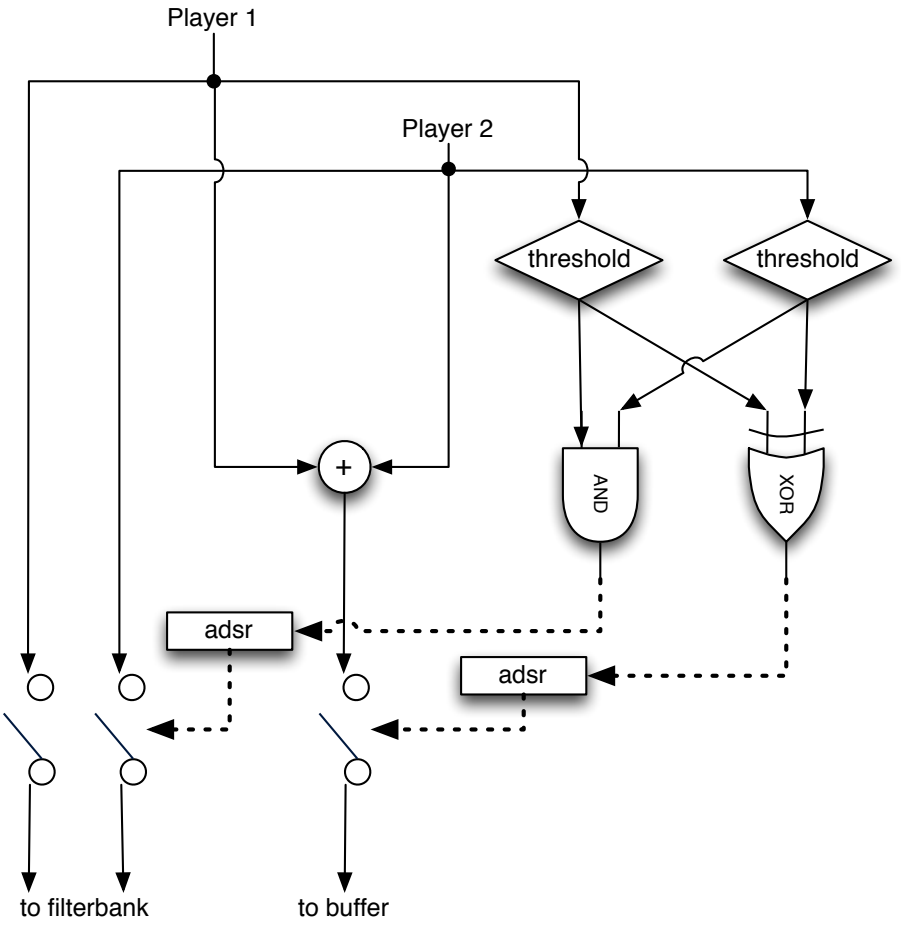


Figure 10.4: Determining co-action

The thresholding mechanism used is adaptive (Figure 10.5), in order to try and cope with the possibility of the players having different and varying levels. A metronome (or, indeed, any other pulsing device) collects sample maxima and minima for the period since the last pulse, and a median of these, $\frac{A+B}{2}$, is returned.

10.2.4 Sub-band Processing

A number of things happen in the filter bank, which is coded as a set of parallel voices running adaptive bandpass filters at different frequency bands. The current implementation of the filter code limits us to eight voices, although I

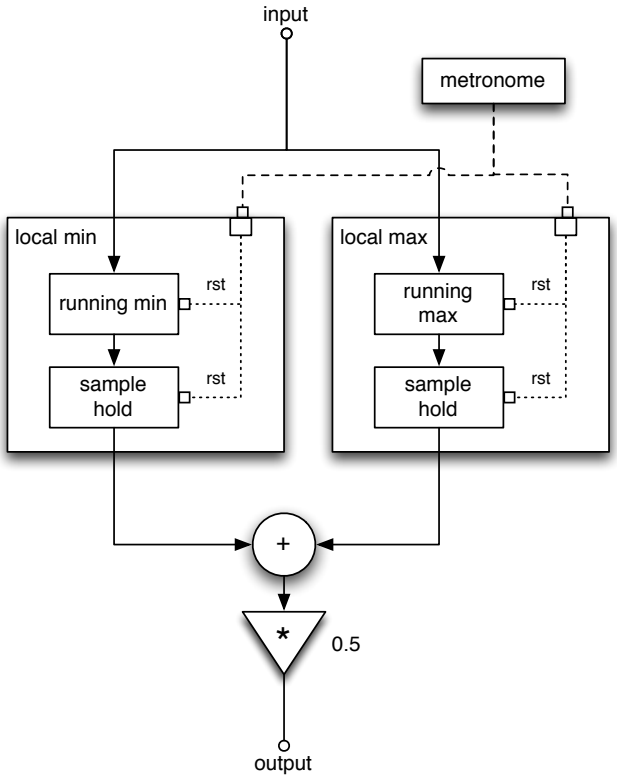


Figure 10.5: Adaptive thresholding

hope to improve this. The filters centre around 100, 200, 300, 500, 700, 1100, 2500 and 3500Hz.

Figure 10.6 shows what goes on in one of these voices. The signals from the players and the room are all passed through adaptive filters designed to follow the most dominant tone in their passband. The complex-valued output of the filters is then used as the basis for further processing.

The players' signals are both ring modulated and summed, before being combined with the room tone. The summed signal is used also as the basis of the warping block.

10.2.5 The Adaptive Filter

The adaptive filters follow a design by Kumaresan, Peddinti and Cariani (2012). The signal is first passed through a fixed bandpass filter, centred around the band of interest. The adaptive part is then made up of three sep-

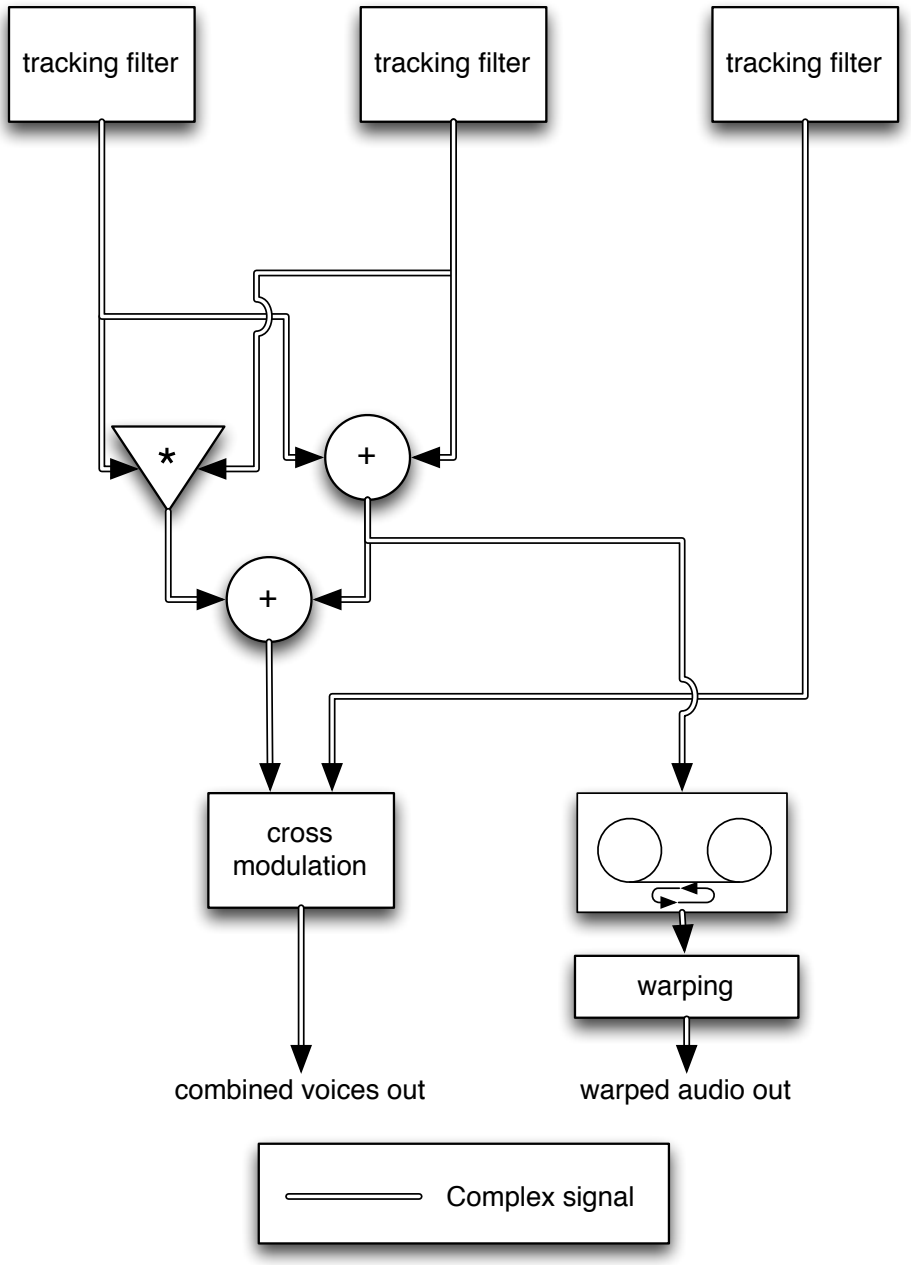


Figure 10.6: Single filter voice

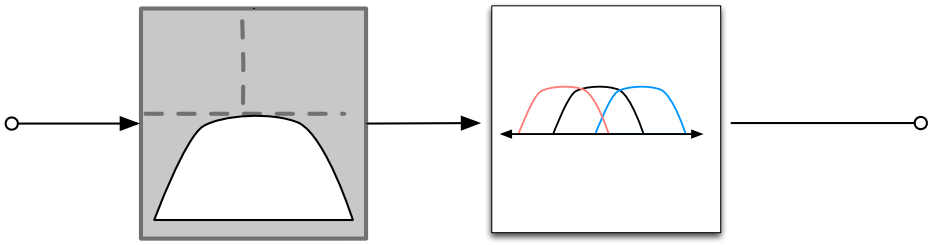


Figure 10.7: Adaptive filter front end

arate filters (Figure 10.7). The central filter is the only one we hear, whilst the other two, equidistant from the centre, are used for tuning.

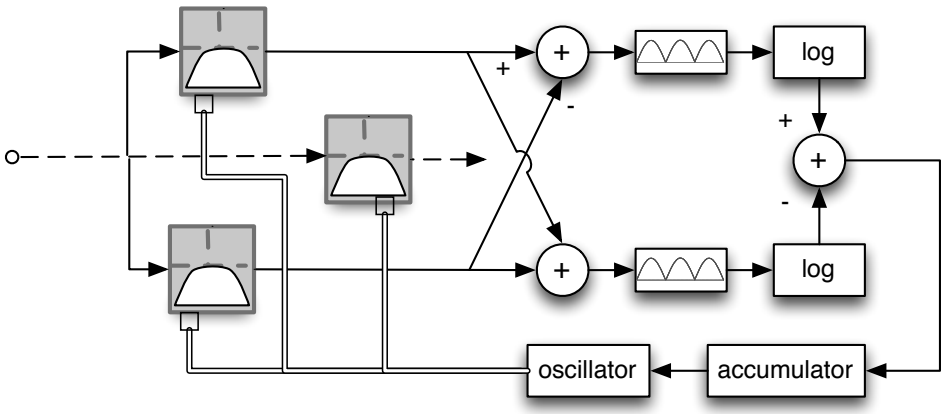


Figure 10.8: Adaptive filter error loop

The tuning mechanism works by comparing the difference of the log signals of the upper and lower filters. This signal is accumulated, and drives an oscillator, which tunes the filters (Figure 10.8). When the error is 0 (i.e. the upper and lower filters have equal energy), the oscillator does not move.

10.2.6 Cross Modulator

The cross modulator shown in Figure 10.9 attempts to superimpose the amplitude characteristics of the player's signal on the spectral character of the room tone (making for a quite noisy signal). Doing this straightforwardly with the magnitude of one and the phase of the other from the filter outputs

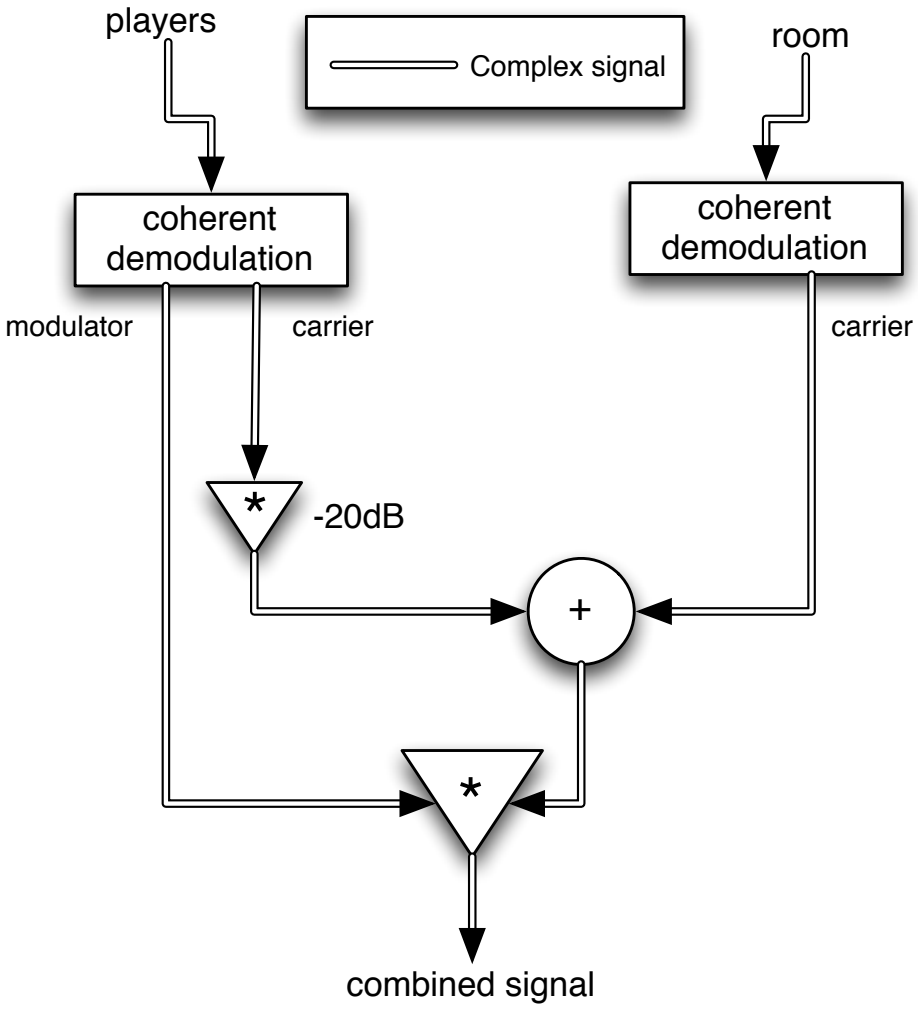


Figure 10.9: Cross modulation block

turned out to be unsatisfactory, as it is hard to guarantee that such signals are properly band-limited when demodulated, which generates a great deal of uncontrollable aliasing and digital noise. To ameliorate this, we use a *coherent*

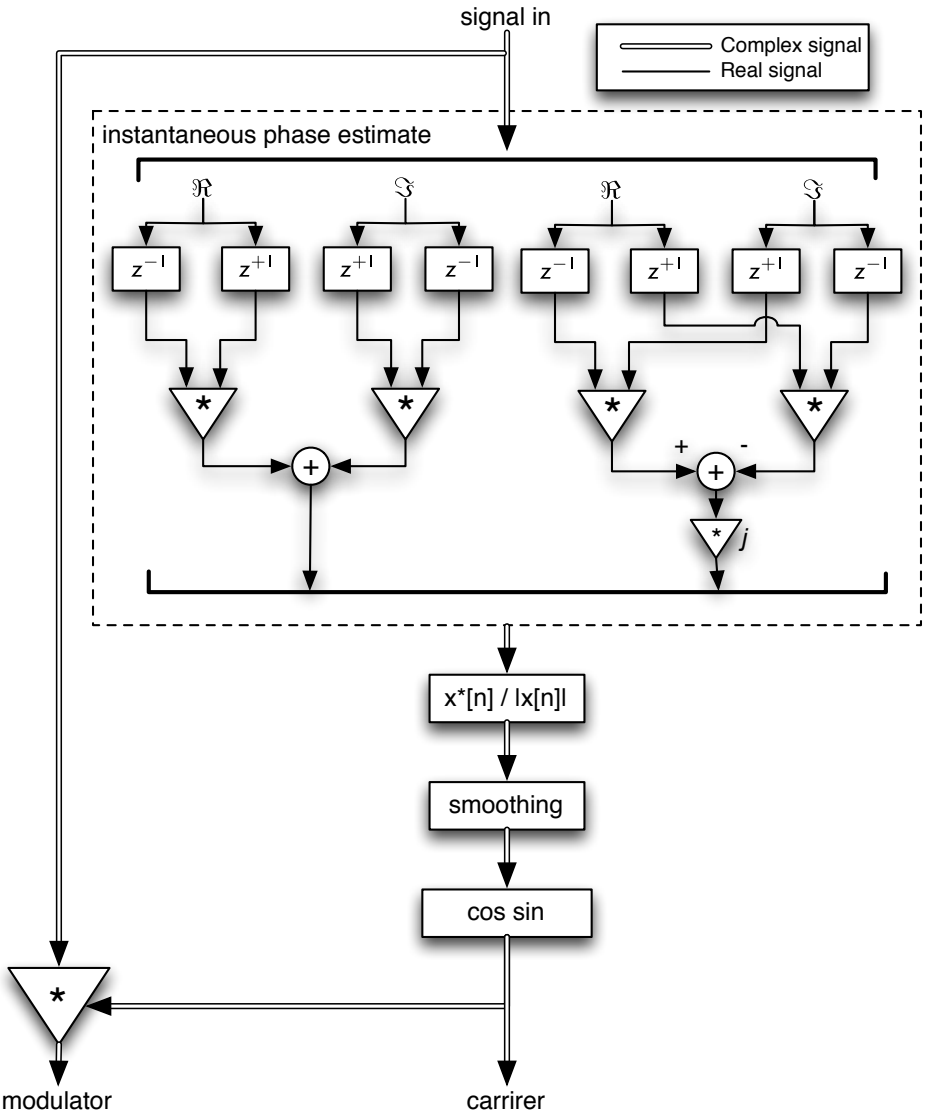


Figure 10.10: Coherent demodulator

demodulation approach (Atlas and Janssen, 2005) to extract the amplitude modulator from its carrier, in that it is based on an attempt to make use of knowledge about the frequency of the signal to extract a smoother envelope and carrier. The scheme is shown in Figure 10.10.

The complex instantaneous phase of the complex-valued input, $z[n]$ is estimated by

$$\begin{aligned} i[n] &= \Re(z[n]) \\ q[n] &= \Im(z[n]) \\ \Re(u[n]) &= i[n-1]i[n+1] + q[n-1]q[n+1] \\ \Im(u[n]) &= j(i[n-1]q[n+1] - i[n+1]q[n-1]) \\ \phi[n] &= \frac{u[n]^*}{|u[n]|} \end{aligned}$$

Where $\Re$ and $\Im$ are real and imaginary parts respectively, x^* is the complex conjugate of x, $|x|$ is the magnitude of x.

This estimate can be differentiated to instantaneous frequency and smoothed, before being used to construct a carrier. Demodulation is achieved by the complex multiplication of the original signal with the conjugate of the carrier.

$$\begin{aligned} c[n] &= \cos(\langle\omega\rangle n) + j\sin(\langle\omega\rangle n) \\ m[n] &= z[n]c^*[n] \end{aligned}$$

where $\langle\omega\rangle$ is the time averaged instantaneous frequency.

This approach needs further investigation, as it still has not lived up to my hopes in terms of the rich variety of sounds I expected to be able to explore this way. A next step is to combine the coherent demodulation with the instantaneous complex frequency techniques developed in ***Cardboard Cutout*** (see Section 8.2.7).

10.2.7 Warping

The final sound producing component of the filter voice is the warped resynthesis, shown in Figure 10.11. Frequency and amplitude tracks from the summed players' signals (incoherently demodulated this time for extra dirt) are recorded to a sample buffer and played back at different speeds, which yields satisfyingly glitchy noise.

10.2.8 Post Filter Control Signals

In each filter block, additional calculations are made that are aggregated across the bands into two control signals after the filter block.

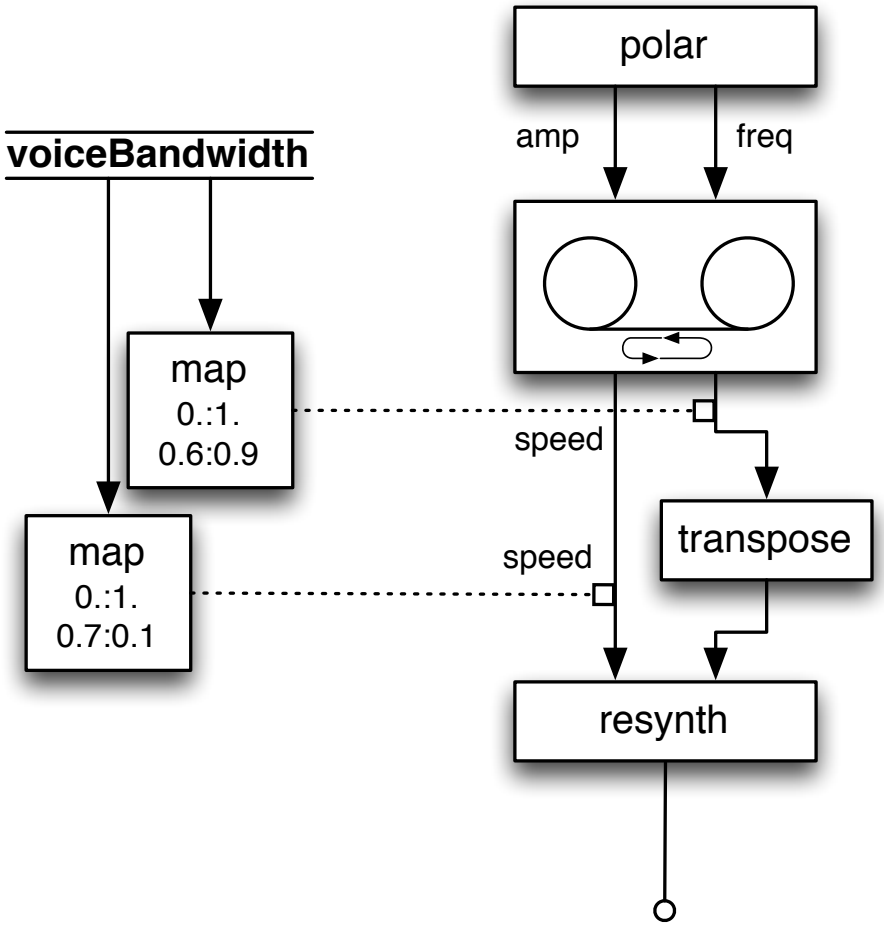


Figure 10.11: Warped re-synthesis

The first of these calculates a sum and a difference of the signal with a delayed version of itself. The delay is proportional to the filter length (inversely proportional to frequency, that is)

$$x_{sum} = x[n] + x[n-d]$$
$$x_{diff} = x[n] - x[n-d]$$

These individual sums and differences are summed into two channels at the outputs of the filter block, and used to estimate spectral **flux**, following a

technique by Risto Holopainen (2012)

$$flux = \frac{\sum_{i=0}^{N-1} x_{diff}[n]}{\sum_{i=0}^{N-1} x_{sum}[n]}$$

The second sub-band control signal is based on an estimation of the current signal bandwidth, derived by tracking the deviation of instantaneous frequency from the adaptive filters' current estimates. Within the individual voices, the sub-band bandwidth estimate, **voiceBandwidth** is used to modulate warped re-synthesis above. The sub-band estimates are summed at the filter outputs and normalised into an aggregated measure, **avgBandwidth**.

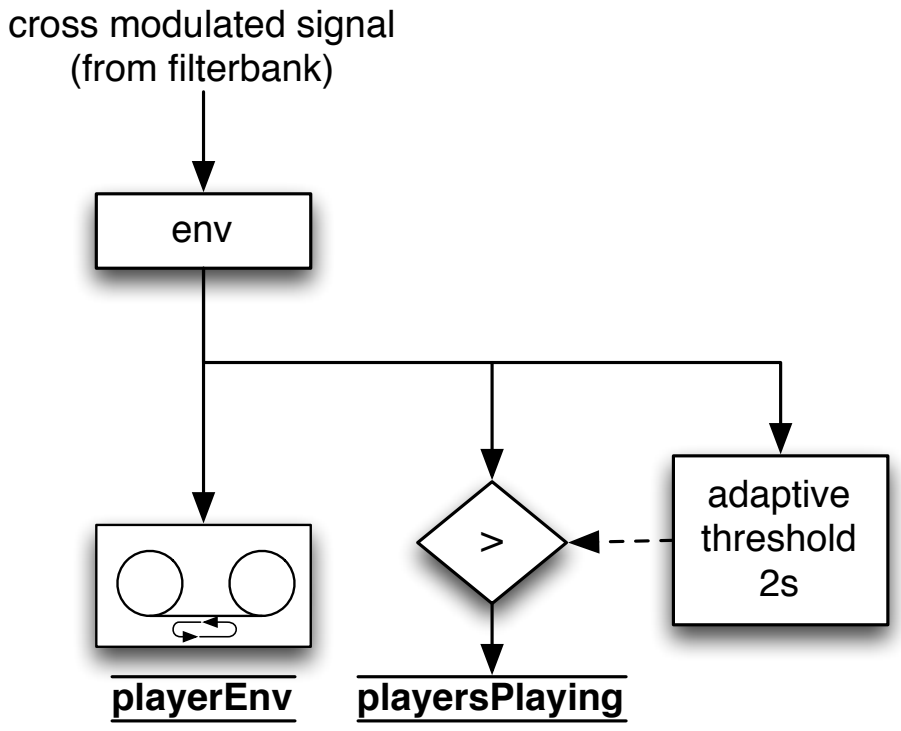


Figure 10.12: Output Features

Two further control signals are derived at the outputs of the filter, this time using the combined player-room synthesis, shown in Figure 10.12. One is simply an envelope, **playerEnv**, derived using the scheme shown in Section A.1. The other is a switch that indicates whether the filter is currently outputting, **playersPlaying**, that uses the same adpative thresholding shown in Figure 10.5.

10.2.9 Whispers, Room Tone and Warping

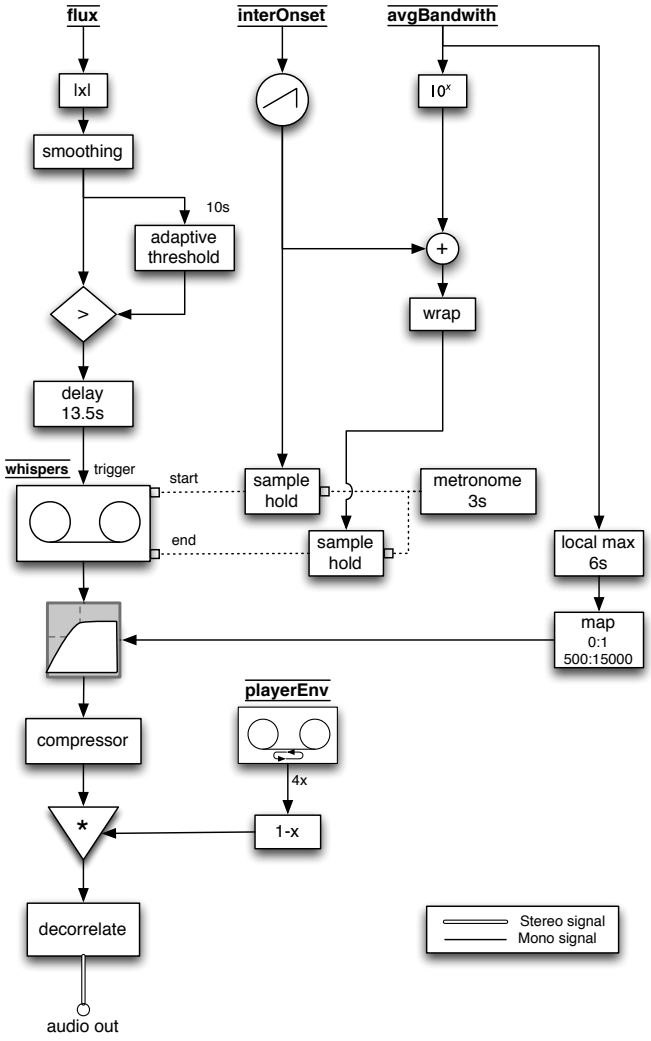


Figure 10.13: Whisper Voice

The remaining computer voices are based around sample playback. The **whispers** voice uses as material sounds from the players when one, but not the other, is playing. The control block for this process is shown in Figure 10.13. Samples are triggered by changes in **flux**, and the length and position of these in the buffer is controlled by **interOnset** times, and the **avgBandwidth**. The signal is highpass filtered, sometimes as high as 15kHz, as the filtering process leaves a deal of unoccupied space at the top. This signal is then

compressed using the scheme shown in Section A.4, and modulated with the inverse envelope of **playerEnv**.

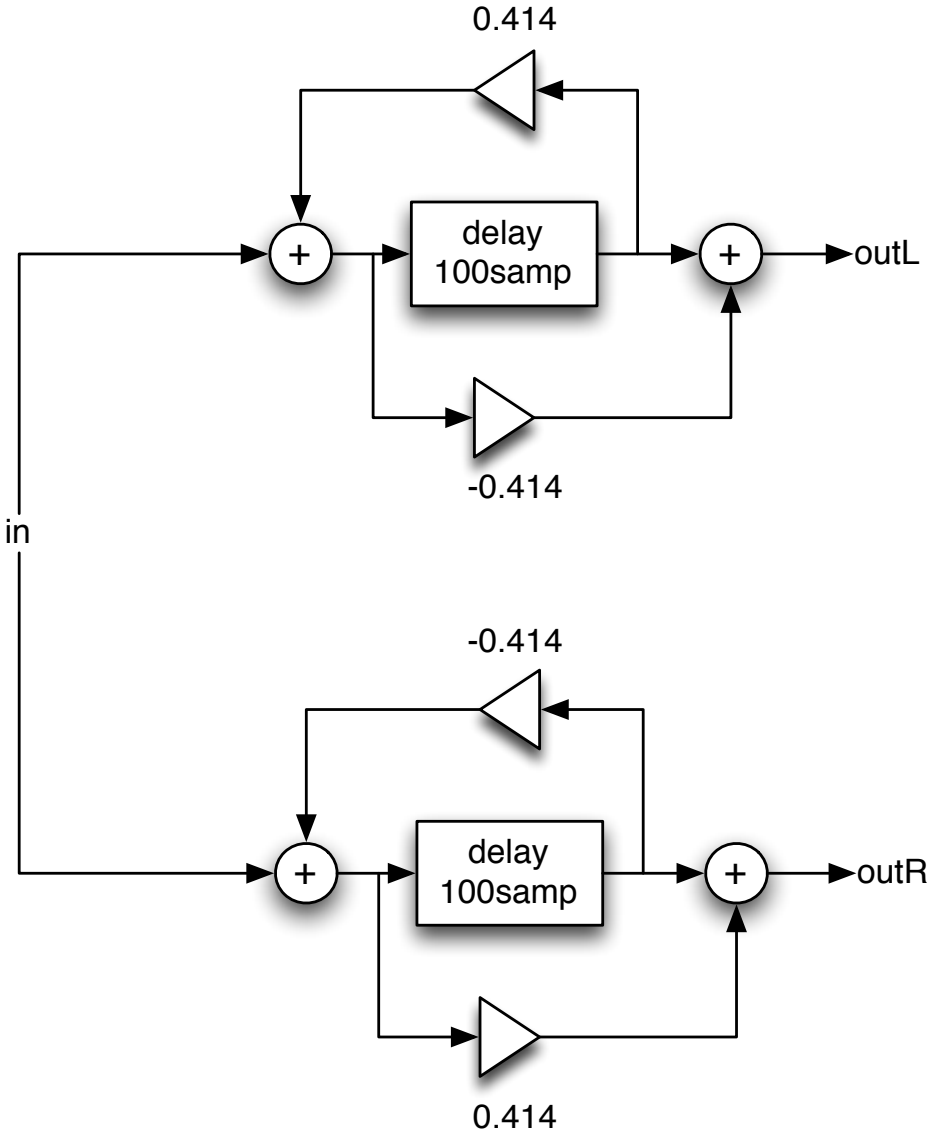


Figure 10.14: Decorrelation with all-pass filters

Finally, the mono signal is turned into two decorrelated signals to make a nice, un-localised stereo spread. The approach taken here follows Vickers (2009), and simply uses a pair of all-pass filters (Figure fig:sd:decorrel).

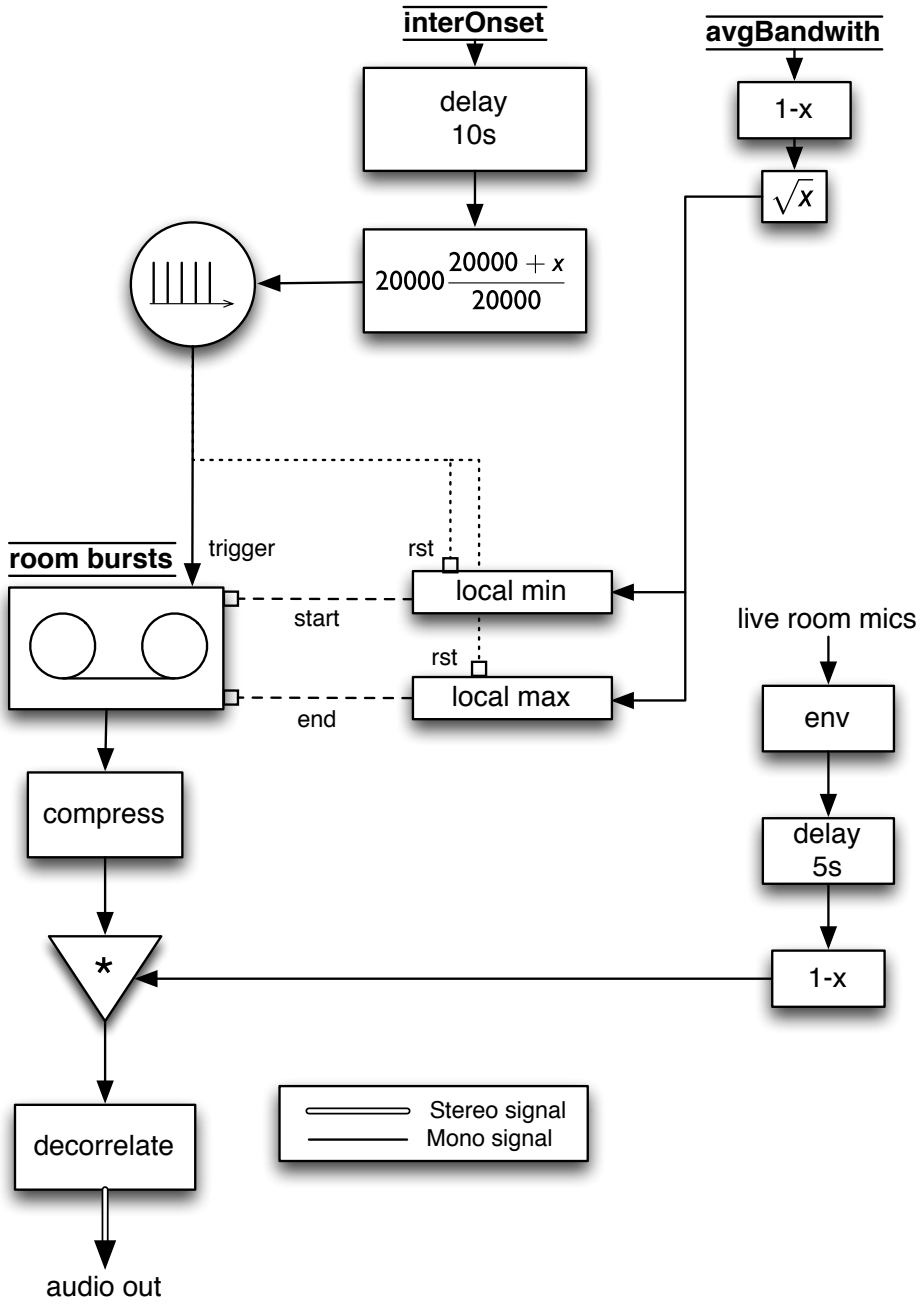


Figure 10.15: Room tone bursts

The **roomBursts** computer voice is driven in a similar way (Figure 10.15). Samples are triggered from the **interOnset** pulses, and the sampler characteristics driven by the **avgBandwidth**. The signal is again compressed and re-modulated, this time using an envelope derived from a delayed feed from the room microphones. Finally, the same decorrelation process as above is used to produce a stereo signal. Before being sent to the loudspeakers, the warped resynthesis is also subject to additional amplitude modulation, based upon the **playerEnv** and **playersPlaying** control signals, as shown in Figure 10.16. Again, the signal is decorrelated before output.

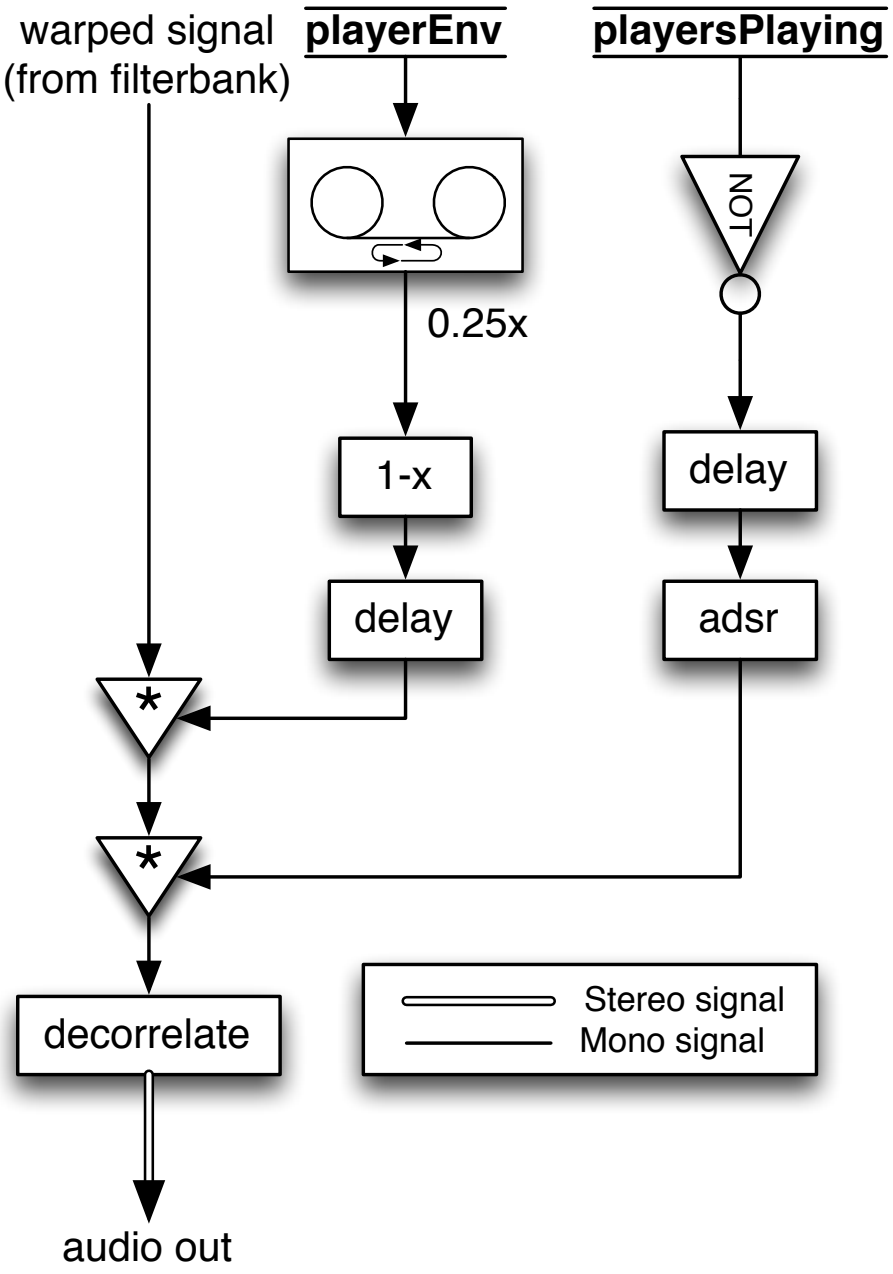


Figure 10.16: Modulation of warped signal

Appendix A

Shared Technical Constructs

A.1 Envelope Follower

This envelope follower design comes from one used by Agostino Di Scipio in his *Audible Ecosystemic* pieces. A standard leaky integrator is followed by a comb filter with high feedback. This recovers a good deal of the gain lost in the leaky integrator, but care is required to ensure stability. In Max/MSP, and other environments that have no enforced -1:1 limit on signals, the feedback path of the comb filter can blow up very quickly. As such it is necessary to place a clipper *before* the feedback path to keep values well behaved.

The smoothing factor of the integrator is expressed in units of time, and the resulting coefficient is $\frac{1}{f_s \tau}$, where f_s is the sampling rate, and τ is the time constant in seconds. Typical values vary between 1 and 100 ms.

Different combinations of long and slow times between the integrator and comb filter will produce different behaviours. Very long delays (>=100ms) in the comb filter will produce noticeable patterning. Typical feedback levels are between 0.85–0.999. At the the high end, the comb filter acts almost as a switch, jumping to 1 very quickly for almost any level of input.

This block is always followed by a downsampling operation, usually to 1kHz, as the comb filter produces significant oscillations that downsampling helps suppress .

Additional self-regulation can be achieved by feeding the output back to scale the input gain.

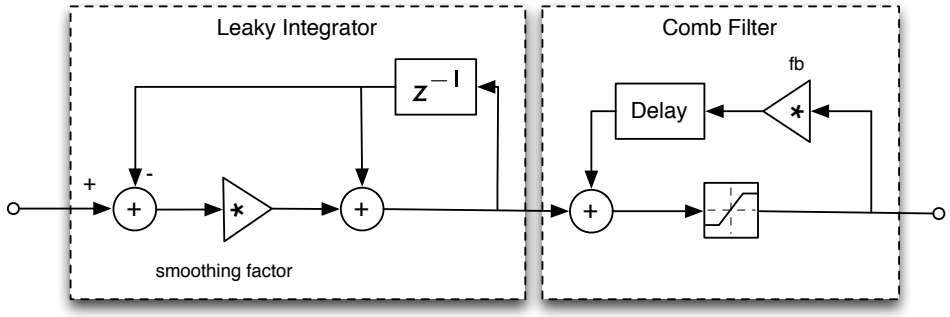


Figure A.1: Envelope follower with integrator and comb filter

A.2 Impulse Follower

This is a very approximate approach to detecting transients. The general rationale is that by comparing levels of difference over some given delay, we get an impression of the temporal flux of the signal. Two differences are taken - a standard backward difference, and a three-point central difference. These are normalised to the range 0-1, and a transient signal is constructed from their euclidian sum $y = \sqrt{diff_1^2 + diff_2^2}$. This signal is then thresholded.

A.3 Wobbly Pulse Follower

The wobbly pulse follower uses autocorrelation, which is commonly used to track pitch in signals, to attempt to find longer term underlying time scales in a signal. Autocorrelation is a measure of how similar a signal is to delayed versions of itself, and is commonly calculated using an FFT over a shortish window (e.g. 1024 points at 44.1kHz is about 43ms).

We are interested in much longer time scales here, so to keep the calculations manageable the input is resampled at a significantly lower rate, which dictates the kinds of time scale detected. For instance, down-sampling a 44.1kHz input by a factor of 8192 gives a new rate of about 5.4Hz (186 ms per sample). A 256 point window is then used for measuring the autocorrelation, meaning that the maximum lag observable is about 47.5s.

Note that what I am not attempting here is a beat tracker (which attempts to find an underlying metric pulse), but to find time scales that are musically congruent, but could shift about radically from instant to instant.

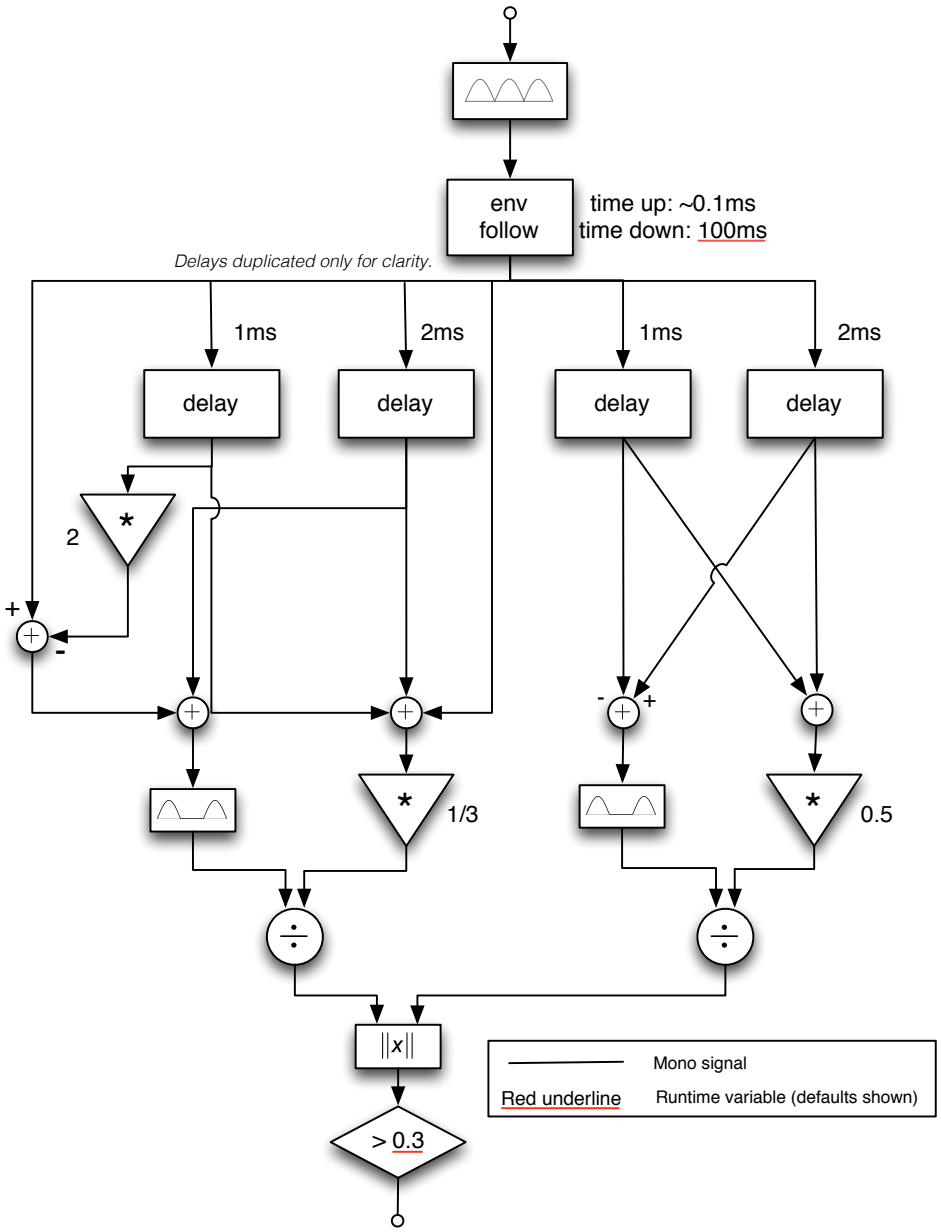


Figure A.2: Time domain transient detector

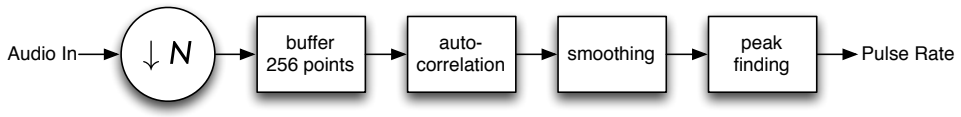


Figure A.3: Wobbly Pulse Follower

With this in mind, the follower has two modes, frisky and non-frisky. In non-frisky mode, the peak autocorrelation (disregarding zero-lag) is followed in a standard way. In frisky mode, a more arbitrary tracking of the 6th peak from the longest end of the window is followed, which produces something less predictable.

A.4 Slam: Signal Leveller

This is a deliberately brutal dynamic range compression device, used for inflating up very quiet signals. The general assumption is that some steps will be taken to restore dynamics with amplitude modulation.

The mechanism simply involves adjusting the gain such that a slow envelope of the signal is always around -23dBfs. Fast peaks are additionally squashed to prevent too many overs. See Figure A.4.

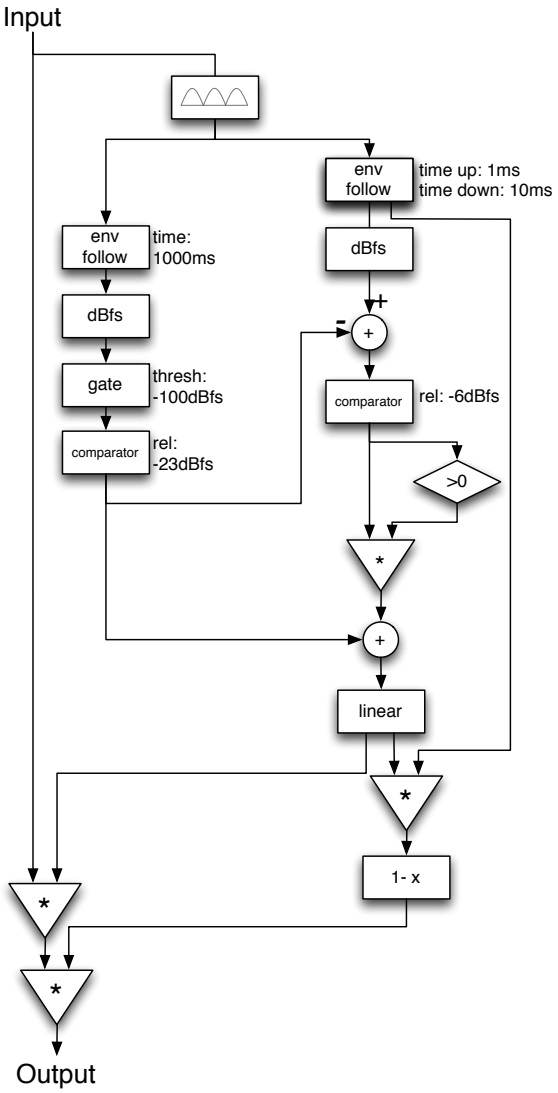


Figure A.4: Dynamic Range Squasher

Appendix B

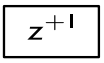
Symbolic Conventions

Table B.1: Symbolic conventions used for block diagrams

	Adder where - and + appear by inputs, indicates subtractor
	Multiplier
	Divider
	Loudspeaker
	Looping memory access. Signals going in are recorded, coming out are played back (e.g. using a combination of [buffer~], [record~] and [groove~] in Max/MSP
	Greater / less than operation, returns 0 / 1
	Convert to dB, i.e. $x_{dB}[n] = 20 \log_{10}(x_{lin}[n])$
	Convert from dB to linear $x_{lin}[n] = 10^{\frac{x_{dB}[n]}{20}}$
	Full wave rectifier, $y[n] = \lvert x[n] \rvert$
	Half wave rectifier $y[n] = \begin{cases} 0, & x[n] <= 0 \\ x[n], & x[n] > 0 \end{cases}$

Euclidian norm of inputs: $\|\mathbf{x}\| = \sqrt{in_1^2 + in_2^2 + \cdots + in_n^2}$

One sample delay



One sample advance

Switch

Attack-Decay-Sustain-Release envelope generator

Change in x = x[n] - x[n-1].

Low pass filter

Band pass filter

High pass filter

Downsample by factor N

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