



KUNGL
TEKNISKA
HÖGSKOLAN



CID-195 • ISSN 1403-0721 • Department of Numerical Analysis and Computer Science • KTH

Improvising Machines Ethnographically Informed Design For Improvised Electro-Acoustic Music

John Bowers



CID, CENTRE FOR USER ORIENTED IT DESIGN

John Bowers

Improvising Machines Ethnographically Informed Design For Improvised Electro-Acoustic Music

Submitted for examination for the degree of Masters in Music by Research

University of East Anglia, Norwich, UK

Report number: CID-195

ISSN number: ISSN 1403 - 0721 (print) 1403 - 073 X (Web/PDF)

Publication date: 2002

E-mail of author: bowers@nada.kth.se

Reports can be ordered from:

CID, Centre for User Oriented IT Design

NADA, Department of Numerical Analysis and Computer Science

KTH (Royal Institute of Technology)

SE- 100 44 Stockholm, Sweden

Telephone: + 46 (0)8 790 91 00

Fax: + 46 (0)8 790 90 99

E-mail: cid@nada.kth.se

URL: <http://cid.nada.kth.se>

Improvising Machines

Ethnographically Informed Design For
Improvised Electro-Acoustic Music

John Bowers

Submitted for examination for the degree of Masters in Music by Research

University of East Anglia, Norwich, UK.

□ 2002

The right of John Bowers to be identified as the author of this work has been asserted.
The contents of this work should not be reproduced without the permission of the author,
except for the purpose of limited, attributed quotation.

Improvising Machines

John Bowers

Abstract

This dissertation is concerned with the improvisation of electro-acoustic music from musicological, aesthetic, practical and technical design standpoints. Detailed ethnographic descriptions of the author's performance experience are offered alongside accounts of software applications which have been developed to support the improvisation of electro-acoustic music. A CD accompanies the submission. Chapter 1 examines various positions regarding improvisation in the musicological literature and the writings of various composers and critics. It is argued that we should resist any theoretical opposition of improvisation to composition and follow an ethnographic turn whereby we treat 'improvisation' as a member category and examine its significance in the hands of those who use the notion. A variety of the world's musics are considered from this standpoint including an examination of recent musicological work on jazz. Chapter 2 opens by presenting electro-acoustic music as indigenously a 'machine music' and develops with an extended ethnographic treatment of the author's concert experience as an improviser in this idiom. Special consideration is given of observable variations in forms of technical interactivity, social interaction and musical material which exist across the various documented performances. A number of well-known theorisations of electro-acoustic music are discussed on the basis of this analysis. An aesthetic specific to improvised electro-acoustic music is formulated in terms of exhibiting the variable relations people can have to technologies and each other in a machine world. Chapter 3 turns to questions of technical design drawing from the ethnographic findings and the proposed machine music aesthetic. An 'against the grain' research agenda is proposed followed by five demonstrator applications which have been used in performance by the author. Three improvisations are discussed for their effectiveness in pursuing aesthetic goals and for what they reveal about the usability of the demonstrators. A variety of strategies for future work is discussed.

—

Contents

Chapter One
Improvising
1

Chapter Two
Improvising Machines
27

Chapter Three
Machines
54

Appendix
Screenshots
81

References
95

Chapter 1

Improvising

I am playing a concert of improvised electro-acoustic music in front of a small audience at Fylkingen in Stockholm as one part of the Zapruda Trio – Sten-Olof Hellström, Simon Vincent, our various computers, other contraptions and machineries completing the ensemble. It seems to me that a sudden interruption of the ongoing electronic textures by the amplified pieces of metal in front of me is called for. I make a series of expansive, aggressive, percussive gestures with respect to these various pieces of scrap and materials acquired from a modelling shop, culminating with a series of sharp blows from my bare hands. Of course, bursts of metallic and characteristically contact-mike-amplified sounds are heard. But alongside each one of the blows is something less impact-ful, more friction-al, not a squeak exactly, not that comic, a rubbing perhaps. I repeat a sharp blow watching my co-performers closely in case one of them is noticeably coordinating their production of the rubbing sound with my activity. Within the music, I am trying to investigate and diagnose the music. I am trying to find out what is making this sound by analysing a gesture which was involved in its production, all the while continuing to play and fold in my activity with that of the others. They give no sign of any gesture showing close synchrony with mine but, on another blow, one of the hand-held electric fans I have been using falls from the table to the floor. I notice that the rubber wheels at the base of the table are gently moving and that subject to my assault the whole table has lurched several centimetres towards the audience. It is these wheels against the Fylkingen cushioned floor which are making the friction sound. My contact mikes are picking up the vibration through the frame of the table. An unintended instrument has appeared. I move the table around, playing the rubbing sounds, varying their pitch, squeakiness and duration. Sten-Olof quickly finds a synthesiser patch derived from a physical model of friction sounds and the electro and the acoustic engage for a while. I bring the table back to its original position, quickly check my wiring, and look for something else to do.

Incidents like this compress many of the features of improvised music often held to be attractive. For Derek Bailey, it is “the accidental, the coincidental, the occasion” which appeal to him in improvised music making and which particularly derive from interactions with co-performers (Martin 1996). To use a more sociological discourse, improvised music making seems to revel in what Garfinkel (1967) calls the “awesome contingency of everyday life”. The Fylkingen vignette involved accidents and coincidences to be sure but these needed to be folded into the music making both in terms of what I was engaged in myself and in how this was coordinated with the contributions of others. There is further contingency here. The unanticipated rubbing sound did not cause the music to stop, but could have done. The movement of the table did not cause the contact mikes to become unplugged, but that too could have happened. The sound could have passed unnoticed or undiagnosed or unexploited or have been ignored by co-performers. On this occasion, these outcomes did not occur and instead the sound *became* a musical material.

It is improvisation as a practically organised form of music making that is the subject of the current work. I am interested in the contingencies – the haeccities if you will – of performance and how these are managed, negotiated and capitalised upon by performers. I am interested in whether music produced under these practical circumstances comes to have characteristic forms. That is, I am interested in relating musical-formal considerations to the practical activities of music makers. In particular, I am concerned with how electronic and computational technologies for improvised music making should be understood from this perspective and designed accordingly. Electro-acoustic music is particularly prominent for study as it ties together technology and music performance in intimate ways, as well as happening to be the music that I work in. Throughout, I try to effect a three-way balance between an engagement with the music literature on improvisation and electro-acoustic music, alongside technical-constructional work, and accounts of practical experience. I hope that the current work has a conceptual, technical and practical yield, albeit of a preliminary sort, but nevertheless one which can enable further developments by myself and others. Along the way, I want to make some passing – yet hopefully suggestive – comments about a number of other topics which you may have also detected in the Fylkingen incident: notions of musical gesture, interaction, texture, interruption, performance as an embodied practice, ‘emergent’ instruments, the relationship between electronic and acoustic sound sources, physical models and metaphors in music and so forth.

Improvisation: The Very Idea

The improvisation of electro-acoustic music and technologies for it, practically understood, serves as my topic. But this seems to be a string of problematic terms which become no less problematic in their conjunction. Questions seem to be already begged about the notion of improvisation, what can count as a technology, how theory and practice are to be interrelated, not to mention what electro-acoustic music might be. Fully addressing all these matters is beyond the remit of this work but some clarifications are in order. In particular, the rest of this chapter is devoted to the notion of improvisation in music and what conceptually and practically we are to make of it. Matters to do with the nature of music technology and its

design and use in electro-acoustic music are more in focus in the next chapter.

Definition is not an innocent act. Whenever an author engages with terms like ‘improvisation’, which can be found in both member’s discourse (that is, in improvisors’ talk) as well in the various and contested theorisations of musicological study, any act of definition will also involve taking sides. Indeed, from time to time, various explicit educational, social, moral and political agendas have been read into improvisation both as a concept and as a practice. To avoid this situation, scholars sometimes take a path of abstraction and seek a notion of improvisation which is designed to fit all occasions. Unfortunately, this runs the risk of offering rather bland elucidations which lose their musical specificity and analytic usefulness.

Improvisation and Composition

For example, numerous approaches to improvisation counterpose it to composition. Notoriously from time to time, this has been done to devalue improvisation by a number of prominent composers and theorists. Adorno (1936/1989) is often taken as devaluing improvisation relative to the serious painstaking work of composition as part of his attack on jazz. Certainly, Adorno seeks to discredit any claim that might be made on behalf of jazz as embodying a sense of musical freedom or offering any foreshadowing of potential political liberation. The mere adornments of jazz do not produce a music separate from its basis in the popular tunes of the culture industry, still less one which could serve as a critique of the administered life. In the 1936 essay Adorno is principally concerned with debunking those who would have exaggerated *pretensions* for jazz with regard to the value of improvisation, rather than debunking improvisation *per se*. Nevertheless, his treatment of jazz makes for a strong contrast with his detailed analyses of the composers he admires (Beethoven, Mahler, Schoenberg, Berg), all of whom are presented as grappling with complex musical ideas in a protracted painstaking activity of compositional work (see also Witkin 1998).

The composer and bass player Gavin Bryars in an interview with Derek Bailey in the second edition of Bailey’s *Improvisation* book (1992) gives a similar picture of composition in relation to improvisation. Bryars admits being to being a lapsed improvisor because he is now interested in ideas which require formulation and working through outside of the real time of performance. Bryars does so without prejudice to improvisation and indeed more recently (1998) he and Bailey have reformed the improvising trio Joseph Holbrooke with percussionist Tony Oxley. Nevertheless, he along with Adorno counterposes improvisation with composition in terms of the nature and complexity of the ideas which can be worked with.

In a lecture attended by the author, a well known electro-acoustic music composer who is also known for occasional improvisations expressed the concern that his improvisations can be a species of “showing off” whose “arrogance” contrasts with the hard work and modesty of compositional work. While the composer confessed to feeling flattered by the applause given to his improvisations, he was distrustful of it and its effects on him. For these reasons, a practice of “forensic” composition where the inner workings of recorded sound are studied and manipulated in detail was to be preferred.

For Schoenberg (1967), improvisation has a role in compositional work – but privately so, as the composer formulates, refines and works through “the musical idea”, which will be ultimately realised by necessity as a notated work. This notion of improvisation or extemporisation as part of ‘pre-composition’ is commonly heard. For some writers, such activities are an acceptable part of the hard work of composition but, if left as an end in themselves, might engender primitive musics. In the third edition of *Grove’s* (1935), H. C. Colles has it that extemporisation is “the primitive act of music-making, existing from the moment that the untutored individual obeys the impulse to relieve his feelings by bursting into song. Accordingly, therefore, amongst all primitive peoples musical composition consists of extemporisation subsequently memorised” (also quoted in Nettl 1998).

Also unsympathetic to claims of musical value in improvisation and, perhaps surprisingly echoing Colles, Boulez (1976) suggests that improvisations will be confined to a stereotypical “curve of invention: excitement-relaxation-excitement-relaxation”, “a sequence of negations”. “Inadequate memory” is blamed for these structures and it is claimed that “the mind is incapable of mixing certain elements”. Forms and structures which are realised over longer periods of musical time, such as those associated with late and post-serialist composition, would exceed the limits of memory and have to be thought through outside of performance and realised notationally. Otherwise Boulez claims only music will arise which is reminiscent of that in the rituals of “so-called primitive societies... whose relatively simple form involves a building-up of psychological tension followed by relaxation”. Boulez’ polemic continues aggressively:

Instrumentalists do not possess invention – otherwise they would be composers... True invention entails reflection on problems that in principle have never been posed... and reflection upon the act of creation implies an obstacle to be overcome. Instrumentalists are not superhuman, and their response to the phenomenon of invention is normally to manipulate what is stored in memory. They recall what has already been played, in order to manipulate it and transform it.

Underlying many of these positions – no matter how cultural imperialist, polemical or straightforwardly insulting they may be – are some core commitments of modernist music. Music is the expression of musical ideas. Properly radical modernist ideas are not easy to formulate, refine or materialise. It needs hard work. This hard work, composition, cannot take place in the real time of performance before an audience. Hence, music which does get created before the very ears of an audience might be novel in its appearance but not in its essence, in the ideas it expresses. As it cannot be modern, it must be primitive.

Presenting improvisation as marginal or parasitical to composition or sometimes a feature of the interpretation of composed works (e.g. Haas 1931) has been common in musicology. In part, this has been for methodological reasons. A musicology which founds itself on *documents* – be those published scores, surviving sketchbooks, diaries or recorded reminiscences – would find activities which leave no or little historical trace rather enigmatic (Nettl 1998). Best to marginalise them and prioritise the study of that which is held to be fully the subject of the mature intention of the composer, the notated performable work. However, it is well known that many composers central to the canon of orthodox musicology were also great improvisors: Bach, Handel, Mozart and Beethoven for example. A common treatment here, though, is to present their improvisations as uncannily well realised, highly disciplined works with recognisable forms – sonata-like or whatever. Moser (1955), for example, claims

that Bach and Handel's improvisations, though based on themes given to them by their audience, had the appearance of composed forms. Even if such claims are true, it is easy to see that these moves leave improvisation at the margins of musicological study: those recognisable composed forms can remain the primary focus. As we shall see, contemporary musicological study which takes improvised musics as a serious topic has had to abandon moves of this sort (Nettl and Russell 1998).

Recently, it has become notable for various musicians to take as their avowed topic the hinterland between composition and improvisation. Fred Frith, Bob Ostertag and Simon H. Fell are all examples of improviser-composers who wish to examine this area. Fell's quintet pieces, for example, often involve intricate solos which commonly sound like improvised jazz but which are in fact notated in detail. The listener may have her suspicions that all may not be as it appears when such a solo suddenly gives way to *tutti* playing as a transformed serial theme returns. For his part, Frith (interviewed by Fehrenbach 2002) dates his interest in the interplay between composition and improvisation from how recordings of improvised material were (tape) edited together in making the Henry Cow albums he played guitar on through the 1970s.

Using the recording studio in this fashion was not new to Henry Cow of course, not even if we confine ourselves to electric-jazz-related musics. For example, Miles Davis aroused especial controversy for 1970's *Bitches' Brew*, not just for its extensive use of electric instruments but also for the 19 edits (so few!?) of the opening track *Pharaoh's Dance*. The Fender Rhodes and the razor blade again combine on the album's title track when the 'back half' of a section already compiled from several takes is used to begin the track, the first half of that section appearing nearly 15 minutes later, with another excerpt from the back half closing the track. A formal A...A...A structure is accomplished not only with materials not initially played with that formal role in mind but with their actual played order being reversed on first to second appearance and back again.

Fell (Kelly 1998) uses the term 'xenochronicity' to refer to such practices of excerpition from original played contexts. I would suggest, though, that a contrast can be made between Fell's (especially) and Davis' use of such techniques. The razor blade produces a familiar form out of unusual materials in *Bitches' Brew*. Many (but by no means all!) of the edits on *Pharaoh's Dance* are not noticeable with ordinary listening. They produce coordinated transitions *as if* they had been scored or pre-agreed. In Fell's work, transitions often jar expectation. The effect is not one of seamless editing but of discomfoting juxtaposition. Whatever the musical outcome, in all these examples some counterposition of compositional and improvisatory practices is being experimented with. Whether the goal is seamlessness, radical juxtaposition or irony, it is important to note that such strategies depend upon a relatively stable understanding on the part of musicians and listeners of what composition and improvisation consist of in the musical idioms being worked with. An irony will not be brought off, a juxtaposition not noticed, a compositional form will not be achieved from improvised materials unless the elements have recognisable features which make this element be or sound composed and that element be or sound improvised. In short, heterodox practices like Fell's, Ostertag's and Frith's depend upon orthodox understandings – in particular, orthodox understandings which maintain a distinction between improvisatory and compositional musical practices.

Improvisation and Critique

Durant (1989, p252) opens the symptomatically entitled essay *Improvisation in the Political Economy of Music* with:

Perhaps more than any other aspect of music-making today, improvisation questions dominant directions of musical change... As a procedure, it raises fundamental issues by putting continuously into question – moment by moment, within the activity of music-making itself – the processes of deciding what to play and how to organise or shape musical events or performances. As a social practice, through its challenge to the production and distribution of music in commodified forms, it questions how relationships of music-making are to be represented: economically, legally and aesthetically...

And continues (p253):

As something people do for themselves, too, improvisation stresses independent activity rather than passive consumption... The challenge posed by improvised music might thus be thought to have large-scale political or epochal reverberations, linked to the circumstances in which music is produced, circulated and heard.

In addition to the title and the explicit claims made by Durant here, his whole discourse is one of thinking about improvisation politically and in a spirit of critique. Improvisation “questions dominant” cultural themes and institutions. Improvisation is situated in relationship to the political economic categories of production and distribution of commodities. Improvisation raises questions of “representation”, a political category in this context, and is seen in opposition to “passive consumption”. Durant is explicit about the kind of improvisation he has in mind (p252-253):

During the last 25 years of Western music, improvisation has emerged from its role of being merely one dimension of music which is for the most part composed and notated, to become a specific form in itself: improvised music, ‘free collective improvisation’, ‘free jazz’. Over two decades, it has opposed tendencies which conceive of music less as a social process than in terms of kinds of resulting representation or ‘text’: as a series of compositions, records, videos.

Throughout these passages, the political value of improvisation is intrinsically linked to its opposition to dominant categories of composition, text, commodity and the institutions and economic relations which support and circulate their material manifestations. That is, improvisation opposes institutionally ingrained musics and its critical political value derives from this oppositional relationship. Improvisation, on this account, effects a *negative critique* upon imposed-composed commodity forms. There is a sense in which claiming this possibility for a political value for improvisation mirrors the heterodox impro-compositional practices of Fell and the others discussed above. The values – be they political or musical – derive from negating or juxtaposing recognisable existing practices surrounding composition. Not surprisingly then, on closer examination, Durant goes on to register scepticism about a number of the political claims for improvised music. For example, against a notion of ‘improvisation as liberation’, especially in its more anarchic variants, Durant argues (p271):

Without structuring differences and distinctions, meanings of any kind are impossible. A politics of ‘liberation’ is one of counter-identification and can signal directions for relative change, but it cannot be a condition to which to aspire.

And against a formulation of ‘improvisation as discovery [i.e. as productive of novelty]’

(p273):

... as regards developing a politics of improvised music on the grounds of ‘novelty’ and the possibility of escaping strictures on conventional sound associations, what seems clear is that novelty exists only in situationally specific relationships of transgression and transformation of existing codes, rather than as some ‘pure’ alternative to them: there is no new musical realm to discover that isn’t at the same time a restructuring or reconstruction of the old.

It is worth noting that the same remarks can be made against any situationally non-specific claims to novelty. The politics of modernism in Boulez and some of the other composers discussed above can meet with the very same objection. Invention and novelty *with respect to what criteria, to be evaluated in what context?* As long as concepts like ‘novelty’ free-float without explication, any practice *and its negation* can be legitimated in symmetrical terms. Without contextual and criterial specification, attempts to stage critical engagements between different practices will involve all parties talking past each other or invoking strikingly similar arguments for seemingly opposite ends.

Prévost’s (1995) *No Sound is Innocent* is a forceful and at times elegantly written advocacy of improvisation in the tradition identified by Durant. Prévost too is engaged in a form of musical-cultural-institutional critique in the name of improvisation. In various places in the text, he endorses quite clear distinctions between the activities of composition and improvisation.

The reality of a [sic] improvisation is not that of composition; the concerns of composition are not compatible – and not competitive – with improvisation... Composition and improvisation are different categories of music. Each is weakened when the principles of the other are introduced. When jazz is overly scored then it risks losing its identity as jazz no matter how good the ensuing music might be. Conversely, when composers include passages that are not specific in pitch, position or movement, then they are being dishonest if they do not acknowledge the creative contribution of the improvisors. In such cases the musician should be treated as co-creators and co-copyright holders!

Total improvisation (which admits all sounds and all possible performance strategies) is a process foreign, and perhaps abhorrent, to the conventionally trained musician... The improvisor throws himself into the moment, into some unknown realm of experience... There is no comparable situation for the classical musician, whose skills and disposition are designed to achieve the opposite – to deliver a measured accuracy and a pre-designed expression. (p73-4)

There seems to me to be a tension in this writing between wanting to acknowledge a difference and incommensurability between activities (their relation is “not competitive”) while characterising the activities in ways which make one seem most unappealing. While the improvisor is throwing herself into the unknown, the classical musician is a mechanical functionary of the score. In the above quote, the ellipsis I inserted before “There is no comparable situation for the classical musician” actually contains (p74):

And in the midst of performance a great struggle will be going on, with the musician constantly reorienting himself, making instantaneous adjustments to an evolving psycho-musical situation – which is out of any person’s control. Out of the controlled accident arises a music which can transcend surface logic, that is, the apparent sense of order in the sound. The skittering helter-skelter of a frenzied ensemble passage will force the musician to performance responses hitherto unthought of, whilst the emptiness of silence will dramatise every involuntary movement.

It is all that which is denied the classically trained musician. All that frenzy, all that existential precariousness and thrill. The considerable rhetorical asymmetry in Prévost’s writing lies

uneasily against the thesis that we are merely dealing with two different activities. One is presented in an irresistible fashion, the other as an empty pathology. It is as if Prévost wants to denounce composition and all the institutions that support it but can't always bring himself to. There are less ambivalent passages however.

Composition I argue is not simply (the most advanced?) medium for prescribing a performance, but a subtle prescription for a network of power relations. (p5)

It seems to me no coincidence that just as private property is the basis for the ideology of possessive individualism, so the musical composition has become a cipher for creative genius. Private property and composition are the bases of their respective systems and perhaps they share a similar socio-economic propulsion. (p169)

These remarks place composition squarely in the political economy of music and open up a space for its negation to be revalued. In particular, Prévost argues for what he variably calls 'dialogical heurism' or 'heuristic dialogue' as a positive organising principle for improvisation: improvisors find things out (the heuristic part) in dialogue. These formulations are attractive but without further specification, they are open to the objections we have already seen Durant raise. Whether something is 'found out' (or discovered) needs to be appraised in a context and with criteria. Without that further specification, there seems to be no in principle difference between Prévost's improvisor and Boulez' problem solving composer – both are doing things heuristically. Durant (1989) sees similar difficulties with the 'improvisation as dialogue' formulation.

... in a procedural description of improvisation such as 'improvisation as dialogue' or 'improvisation as problem-solving' there are no guidelines concerning what will be a 'problem' or what might constitute a resolution of any such problem... the attractiveness of the activity – as well as its claims to stand as a liberating 'free' alternative, or as a way of discovering new sounds and new musical 'meanings' – lies precisely in *not* having pre-ordained objectives. (p274)

In fact, though, Durant detects that sometimes:

... there *is* a determining, broader theoretical or ideological assumption in the 'improvisation as dialogue' view: a view of the nature of desirable human relationships and interactions (e.g. co-operativeness, freedom from aggression, etc). And such a view may perfectly well be shared by particular groups of improvisors or by any audience group. In this case, though the music itself merely dramatises and endorses an already established framework of values, rather than constructing or investigating them. (p275)

I can find no direct engagement with objections like these in Prévost's book – even though Durant seems to be targeting an account of improvisation which Prévost is prominently associated with.

A core difficulty in these various attempts at understanding improvisation in the political economy of music is not, to my mind, that music is thought of politically. I am not arguing for a position which sees no role for political debate in musical studies. Rather, I feel that those who advocate improvisation as a politically oppositional cultural form are expecting too much of the music *per se* or are conducting their arguments as if the music alone has a valorised political status or potential effects. Improvised music *may* be a politically and culturally progressive form, it depends (once again) on context and criteria. It also depends on how the music is taken up, that is, on what role it has in settings and activities which are unambiguously political in nature. These are completely open and historically contingent

questions. I can imagine contexts in which the soundtrack of revolution will be improvised. I can imagine contexts where it will be sung by The Sugarbabes or maybe a curious Bob Dylan revival will take place. I can also imagine (contra Durant) a revolutionary cell gaining strength and confidence from their “already established framework of values” being played back to them in a concert of performers in heuristic dialogue just before they engage in sedition against a fascist oppressor. I can imagine all that but I know that the Nazi occupiers demanded the confiscation of radios from the Dutch people (it is claimed) to stop them listening to swing music. It seems arguable that swing, no matter how composed a music, no matter how trifling a product of the culture industry, had a role in popular resistance to fascism in occupied Holland. Indeed, this seems rather more arguable and trading on a clearer sense of ‘the political’ than the ‘in principle’ advocacies of improvisation as cultural opposition within the political economy of music that we have reviewed.

A second core difficulty with many of the arguments we have examined is their persistence with an oppositional construction between composition and improvisation and taking this to map the whole field of debate. The rhetorics often present these activities as uniform and undifferentiated. We have seen little of the variety of activities and strategies which may constitute composition and improvisation. We have not been in an informed position to assess questions of their relation except abstractly or intuitively. A priori we have a limited repertoire of possibilities. Two activities seem to be either compatible, in competition, or incommensurate. Equally we have been presenting debates about improvisation and composition, but improvisation and composition *of what?* Much of the discussion of this section has been about a certain form of improvisation (see Durant’s characterisation) in relationship to modernist Western art-music composition (Durant cites the composers Berio and Boulez and refers generically to the Darmstadt School). This is a rather factional dispute when one considers all the musics of the world and the varied senses in which they can be said to be improvised, composed or created some other way.

Dissolving Improvisation

In the face of arguments like these it is tempting to dissolve the categories of improvisation or composition in definitions like the following (Munthe, n.d.):

Improvisation is the activity of, to some extent, creating and constructing a piece of music in the same time as it is being performed. Improvisation in this wide sense is a necessity in all performed music whether it is called arrangement, interpretation, ornamentation, reading or something else.

Nettl (1998) takes a sample of definitions from music scholarship and finds a surprising and monotonous agreement on this core feature of the synchronicity of creation and performance even if there is disagreement about the value to be attributed to such activity.

In related fashion in an article primarily about music education, Rosenboom (1995) writes:

My definitions for composition and improvisation are quite simple:

A composer is simply, a creative music maker.

Improvisation is simply, composition which is immediately heard, rather than subsequently heard.

Any mixture of these is perfectly feasible. Creative music makers may include creative performers, composers, analysts, historians, philosophers, writers, thinkers, producers, technicians, programmers, designers, and listeners - and maybe most importantly, listeners.

What is striking is how the invocation of this single allegedly self-evident feature of improvisation (creation and performance as coeval phenomena) licenses massively inclusive treatments of improvisation and composition. Suddenly, everyone is a composer (Rosenboom) and all performance involves improvisation (Munthe). Making concepts massively inclusive and eroding differences – no matter how attractive it might appear from a liberal standpoint (and Rosenboom develops a classically liberal inclusive approach to music education in his piece accordingly) – are strategies which remove any analytic value the concepts might have had.

In an interview with Gabriel Fehrenbach (2002), Fred Frith explores a number of different ways of talking about improvisation and composition:

Fehrenbach: Improvisation and composition is [sic] normally seen as something different. You said once, that it's rather nearly similar. Now *Digital Wildlife* show [sic] something like a hierarchy between improvisation and composition. The process of composition, was it a rational one, which was confronted against the moment of improvisation or did itself has [sic] also a moment of coincidence?

Frith: Well you know all the clichés - improvising is 'instant composition', 'spontaneous composition', and so on; interestingly the same kinds of expressions don't exist in the other direction. We don't hear people talk about composition as 'improvisation in slow motion'! Of course there are also prevalent political and economic reasons for that. Existing economic structures privilege composition; and I have a theory that improvisation disappeared from classical music as a result of the creation of copyright laws! I do think that composition and improvisation are different aspects of the same process. What interests me in your question is the use of the word 'rational' - does this imply that improvisation is irrational? Are these words useful in this context? I think the process of creating just about anything involves combinations of rational thought, intuitive choice, ingrained memory, and desire. I could apply all of those words to both composition and improvisation. The process is different, and occupies different time frames, but other aspects are essentially similar.

Frith argues interestingly that the formulation of improvisation as a limit case of composition in terms of the temporality the process is not an innocent affair. That we do not talk about composition as slow improvisation suggests an asymmetry in the discourse and a residual parasitism in these formulations of improvisation upon composition. For Frith, this discursive asymmetry has a material basis. In responding to the interviewer's questions about the rationality of composition, Frith moves to an inclusive way of thinking about creativity. His assertion "I think the process of creating just about anything involves combinations of rational thought, intuitive choice, ingrained memory, and desire" may seem easy to agree with but the important questions are begged: *but how?* and *in what activities?* These questions are begged, not answered by Frith's response. This becomes doubly problematic if we begin to suspect that *what counts as* choice, intuition, memory and desire might also be contextually variable affairs. The exact constitution of activities which can be regarded as improvisatory is a proper topic for an empirically grounded musicology and ethnomusicology of improvisation, not a matter to assume answers to on a priori grounds.

Improvisation as an Ethnomusicological Topic

Musicological and ethnomusicological interest in improvisation is growing. A landmark collection of research on the topic is Bruno Nettl and Melinda Russell's (1998) *In the Course of Performance: Studies in the World of Musical Improvisation*. For the contributors to this collection, improvisation is less a concept to be defined or advocated as the name of an empirical research programme. Consistent with an anthropologically-inspired ethnographic orientation to cross-cultural research, many of the authors do not take the concept of improvisation for granted as picking out a unitary set of phenomena. They are sensitive to the possibility that members of the various musical cultures studied may not use the notion of improvisation or anything like it. Indeed, it is the explication of the categories that members *do* use and understanding the social practices in which those categories are in play which is the proper topic of the ethnographic material in this collection. Accordingly in what follows, I highlight three contributions to this volume to the extent that they justify a turn to improvisation as an empirical topic to be understood in terms of the practices of incarnate musicians. It is this orientation which I will further develop in my treatment of improvisation in electro-acoustic music.

From Persia to Beethoven

Blum (1998) notes that discussions of improvisation in Near Eastern writings commonly emphasise the appropriateness and timeliness of a musician's response to a given performance situation. However, what counts as appropriateness and timeliness must be understood in relation to the kind of performance (e.g. poetry or singing and instrumental music) and the details of the situation (e.g. a performance before a princely patron and a small gathering of guests or a ceremonial occasion). Quoting various Persian sources most dating from the 10th to 12th century, Blum notes that patrons would be likely to highly esteem the improvisatory skills poet-singers able to create new verses on request rather than to present familiar ones. The appropriateness of a performance would often be shaped by a request to respond to the avowed emotional state of the patron. Accordingly, a number of instruction manuals insist that part of a musician's skill is to be able to ignore his own emotional state and chose a melody type which suits the time, the season and the temperament of any listener who is prepared to reward the performance. The ability to spontaneously invent entertaining or inspirational verses before esteemed invited guests would enhance the prestige of performer and patron alike. The values attached to performance are not confined to prestige and reward, though. In many of the ceremonies of Sufism, performance and carefully crafted listening invite the reception of gifts from God.

Blum's main contribution, for our purposes, is to point to the kinds of criteria members employ in their practical appreciation of an improvised performance as appropriate to its situation. These are to do with historically and culturally specific systems of patronage, prestige, reward and understanding divine influence on earthly affairs. In a second part to his piece, Blum continues this theme in an examination of varied and different ways improvisation has been discussed in European music over the last three centuries or so. Blum endeavours to recapture the richness of the vocabularies that have existed in Latin, French,

German and English for describing the quite different phenomena we are tempted to treat together under an inclusive concept of improvisation. Different terms would be used to describe activities in different settings (domestic, religious, concert) or whether the performance was vocal or instrumental. The composer Grétry in 1797 commends “young unmarried women... to improvise [*improviser*] on a full instrument, such as the piano, the harp etc., [as] a source of happiness for lively imaginations”; indeed, a young women’s modesty “is never compromised by unfurling her entire soul in the language of melody” unlike, presumably, what might happen in the case of song. Improvisation here is a discrete, domestic activity in which the sexuality of young women can find a regulated expression. The form of the activity, its setting, the gender of participants, their marital status and the choice of instrument all enter into its characterisation: *improviser* rather than *impromptu* (Blum 1998, p37-38). Being sensitive to the specifics of linguistic usage enables Blum to be rigorous in understanding a remark of Beethoven’s written in 1807 or 1808:

Man fantasirt eigentlich nur wenn man gar nicht acht giebt, was man spielt...

“One is actually improvising only when one is heedless of what one plays” is at best an approximate translation which might miss Beethoven’s emphasis on a particular kind of performance – a ‘fantasy’: man *fantasirt*. For Beethoven here, a fantasy also requires the musician to have a particular kind of relationship to audience response: ignore it.

Javanese Gamelan

Although Javanese Gamelan music is often held to be improvised, one must again be careful in identifying the precise sense in which this might be so. For one thing, the term *improvisasi* is a relatively recent borrowed word in Indonesian and plays little role in the member categories Gamelan players would routinely use amongst each other to discuss their music. Anderson Sutton (1998) presents a nuanced picture concerning improvisation in Gamelan. To be sure, musicians make selections between alternative patterns and they can do this in performance and without prior preparation or discussion. However, a good Gamelan performance does not *require* such of the moment activity. Indeed, Anderson Sutton presents transcriptions of recordings of his own Gamelan teacher Suhardi made over a period of 21 years which show remarkable similarity across performances of pieces. In Suhardi’s own accounts of his practice, he claims not to strive to create new *variasi* but might accidentally or inadvertently play one, or may be forced to play one recovering from error or helping a co-performer out of difficulties. *Variasi* which are found to be attractive might well be retained and played again. (Parenthetically, it is interesting that a borrowed term, *variasi*, is used to describe such activity.) Perlman (1993, p363) presents the contrasting case of a much younger musician Sukamso who described himself as “still searching, still lacking a large enough vocabulary” and willing to imitate others and experiment at rehearsals. The impression one gets from this work is that such experimentation is part of becoming a mature Gamelan player but is less noticeable once a degree of mastery has been achieved. Anderson Sutton (1998, p87) concludes:

[We] must concede that Javanese musicians improvise, but would we wish to characterise Javanese music as improvisatory? I would say not, for the aesthetic emphasis is not on originality, spontaneity, or even planned variability, though for many of the *garapan* parts some degree of variation is both

normal and expected. I would conclude simply by positing that we view Gamelan music performance as the combination of individually composed parts, with relatively little determined spontaneously during performance and hardly anything presented without prior planning. It would not be a contradiction, then, to say that Javanese musicians improvise, but that Javanese music is not improvisatory.

Ecstatic Feedback

While Beethoven's sense of improvising a fantasy discounts an acknowledgement of the audience and the on-the-spot selection of parts seems inessential to Javanese Gamelan, these two features are jointly negated in Ali Jihad Racy's notion of 'ecstatic feedback' as applied to Arabic (Racy 1991) and Hindustani (Slawek 1998) music. Racy argues that for many traditional Arabic musics a condition of 'creative ecstasy' is required for performers and audience alike and many features of a performance and its preparation are concerned with ensuring that participants will experience and communicate it. A detailed vocabulary is available in Arabic for musicians to distinguish different ecstatic states and discuss how to engender them. The production of ecstasy relates to all aspects of the practice of musicianship: training, rehearsal, choice of venue and material, and the conduct of performance before an enlightened audience. The singer Sabah Fakhri told Racy (1998, p95):

I feel delighted when I see the people understanding me and judiciously following what I am performing... Of course, I sense people's reactions from their movements and by observing their responses to what I am singing. In order for me to perform best, first I have to be sure that I am physically in good condition and that I am accompanied by good musicians as well as equipped with an appropriate sound system, one that I have tried out and adjusted in advance. Beyond that it is the audience that plays the most significant role in bringing the performance to a higher plateau of creativity... I like the lights in the performance hall to remain on so that I can see the listeners and interact with them. If they respond I become inspired to give more. Of course, the performer has also to be in a state of ecstasy in order to perform in the most inspired fashion... In a large measure, this state emanates from the audience.

The Arabic musical culture which Fakhri inhabits has no word that can adequately translated as improvisation. Interestingly, Racy claims that there is a sense in which *it does not matter* to a musical culture which accepts flexibility and spontaneity as norms of musical creativity whether an aspect of the music is precomposed or of the moment. Naturally, though, as a practical concern, it is important that a musician has a wide range of strategies available to develop the music and respond in a timely way to the audience in their co-production of musical ecstasy. And it is these strategies, rather than any global notion of improvisation, which form the subject of treatises and musician's talk.

Slawek (1998) endorses Racy's notion of ecstatic feedback in the context of Hindustani instrumental music. He notes too that "musicians crave ongoing audience approval in the form of verbalisations of praise, bodily gestures, and facial expressions of rapture" (p337). It would be wrong to think of these 'cravings' as mere self-indulgence on the part of exploitative performers as again a flexible improvisatory form of music making engendered by musicians in an uninhibited state of ecstatic creativity and responsive to an audience is thought to be constitutive of the performance situation as such. Uninhibited here does not mean without musical precedent. On the contrary, the various musical 'models' of Hindustani music, of which the *raga* are the most well known, are precisely the means by which a large

repertoire of working musical possibilities can be rapidly worked with as the performers follow the imperative to “keep it going” (Slaweeck 1998).

Interim Reflections

Let us take stock of the arguments so far. *First*, I want to claim that ‘improvisation’ is not always a member category – even in musics which do seem to be invented on the spot or in which alternatives are selected without prior agreement. *Second*, when we can identify something akin to the notions of improvisation we might have posited on a priori grounds its role and significance varies widely across the world’s musics as well as within the recent history of Western art music. The questions of the relationship of performer to audience, the role of training, preparation and rehearsal, the significance of instruments and venues are all variable matters. *Third*, viable contrasts or comparisons with composition are also not always available because composition might not be a member category either. Still further: using phrases like spontaneous composition to describe, for example, Hindustani music would be an unfortunate and analytically insensitive imposition of an inappropriate conjunction of inappropriate categories. *Fourth*, the musical practices we have touched upon all point to the intimate ties that exist between the music and the social organisation of the various parties to it. It would be misleading to articulate this in terms of music having a social role, function or aspect. The very contours of a singer’s improvisation in relation to an emotional state avowed by a princely patron are part of how the singer recognisably demonstrates his competence as a singer and as a subject. The ability of a singer to respond to the indications of an audience, and reciprocally the audience to the singer, in the co-production of ecstasy is a reflexive part of the musical-spiritual culture of the participants to such events. *Fifth*, as an alternative to stipulating definitions of improvisation or composition on a priori grounds and valorising one term or the other to justify or criticise a practice, improvisation can be made a matter of empirical study and practical reflection. My intention is to be consistent with this orientation in developing an understanding of what improvised electro-acoustic music might be or become. Before grappling with this in the next chapter, a further area of background scholarship needs to be reckoned with.

Jazz

It is jazz studies of course. A full treatment of the musicological literature on jazz would be impossible in a work of the current scale. Instead, I chose to focus on jazz studies which are consistent with the orientation to understanding improvisation which is beginning to emerge; that is, one which emphasises its practical and social interactional constitution. From this perspective the musicological literature on jazz is surprisingly thin. Most studies are devoted to analysing the musical products of jazz with conventional concerns: melody, harmony, rhythm and so forth. Rarely are these aspects of the music analysed as the social interactional accomplishments they so clearly are. The core role of improvisation in jazz – especially jazz from bebop onwards – cannot be denied. Indeed, here is a form of music where improvisation *is* a member category and where the relationships between any precomposed material which

might form the starting point for a performance and the improvisation which takes place in relation to it are core to its musical specificity. It might seem curious, then, that the majority of musicological work does not take the interactional improvisational production of the music as its core research topic.

A pioneering study like Jost's (1975) *Free Jazz* is largely concerned with the melodic construction of the soloing work of musicians such as Coltrane, Coleman, Shepp and others. These musicians are presented as progressively developing increased freedom in their improvisations. 'Freedom' in Jost's work is especially melodic and harmonic freedom as he charts developments from the modal playing of Coltrane through to Sun Ra's embracing of electronics, textured improvisation and mystical spectacle. That the book ends with Sun Ra is perhaps symptomatic. It ends with the figure of all those discussed who perhaps most resists comprehension in terms of a narrow musicological study of melodic and harmonic variation. This is not to say that Jost's book is narrow in its sympathies. Rather, the methods of melodic analysis so thoroughly on view in the treatment of Coltrane find much less a place in discussions of Sun Ra – where musicological analysis of transcribed notated solos largely gives way to biographical and sociological accounts. Throughout, though, the interactional production of melody and harmony as real time accomplishments in the improvisational moment is not Jost's topic.

It is only very recently that detailed studies of interaction in jazz have appeared. I am not saying that musicologists have failed to acknowledge *that* jazz is produced in the interaction of (a typically small) ensemble of musicians. Not at all. Rather, it is only with work like Berliner (1994) and Monson (1996) that *how* this takes place is the topic of musicological analysis. In short, it is the mechanics of jazz interaction which becomes the topic for these recent writers. Melody, harmony, rhythm, overall formal affairs are analysed against this background. Of course, these writers were not the first to have an interest in jazz in terms of the methods musicians employ in their real time accomplishment of improvised performances. Sudnow's (1978/2002) *Ways of the Hand* presents a detailed ethnomethodological and phenomenological analysis of the author's own acquisition of skill as a jazz pianist. From the very different perspective of cognitive science, Pressing (e.g. 1984) has studied jazz improvisation in terms of putative psychological mechanisms involved in its conduct. However, neither of these authors prioritise interaction within jazz ensembles as their topic which, as I hope to show, is a decisive departure for musicological studies of jazz and one which is especially formative of the perspectives on improvised electro-acoustic music which I will develop.

For the purposes of the current work, I will especially discuss Ingrid Monson's (1996) ethnographic and musical-analytic study *Saying Something: Jazz Improvisation and Interaction* as this author offers interesting connections between a certain characterisation of jazz as an interactional production and its significance in Afro-American culture.

Grooving

Compared with Jost's studies of the progressive melodic invention of individual jazz players, Monson begins with a methodological inversion: it is the collective production of rhythm and

how this is accomplished by the bass, piano and drums which is her starting point (1996, p26-72). Each of these instruments is introduced in turn before any discussion of the melodic activities of soloists. Indeed, Monson's informants insist on the melodic and harmonic potential of each instrument in the rhythm section. A 'walking' bassist can break the pattern to echo or vary one of the 'front line's' melodies. A 'comping' pianist can bring out right hand melodies from an otherwise chordal accompaniment. A drummer can select particular drums to shift the harmonic register of the ensemble or can play short sequences of pitches (e.g. on carefully tuned toms). In short, each instrumentalist has a melodic-rhythmic flexibility which enables varied relationships to be taken to each other and to any soloist who might be playing at the time.

For nearly all of Monson's informants it is the collective production of a *groove* which makes for effective jazz ensemble playing. The groove is an aesthetic ideal but it is also a matter of practical coordination *between* players. It would be misleading to abstract a single 'rhythm line' and treat this as the groove when it is the coordinated activity which matters. For example, clarinettist Don Byron tells Monson that grooving is "a euphoria that comes from playing good time *with* somebody" (p68). Being able to groove, or swing, is an essential feature of properly improvised jazz ensemble performance and can be destroyed with an excessive reliance on prepared parts. Byron again (p84):

I hate hearing them bands where like... one cat's playing some shit that he practiced. Another cat's playing some shit that he practiced. Everybody's playing some stuff that they practiced... On a certain level there's like a feeling, "well, I like playing with you," but I mean, what does that mean?... You know, we didn't play shit together. We didn't do nothing together. I played my stuff, you played your stuff, we didn't screw up the time.

In both of these quotes playing in good time without screwing up is a minimal accomplishment compared with grooving as a band which only comes with flexible responsiveness to others.

Soloing arises on the basis of an already established complex musical sociality established by the groove. Indeed, many of Monson's informants praised admired soloists for their ability to 'colour' the rhythm with pitch choice or to work with a very restricted range of pitches to bring out different aspects of the ongoing rhythmic texture. While a solo changes the relationship between instrumentalists, the groove and its demand for careful listening and responsiveness should not disappear.

I would wish to add that a number of the formal features of jazz can also be discussed in terms of the establishment and maintenance of the groove. By starting a piece with a precomposed section or a well-known popular tune, the ensemble presents themselves with a favourable environment for establishing the groove. By returning to such material between solos or at the end of the piece, the ensemble not only give a formal shape to the music, they also enable the groove to be checked, repaired, improved, modified. I would like to suggest that the formal features of jazz – and the role that jazz composition often plays – should be understood in terms of the maintenance of interaction and participation amongst members of the ensemble. I do not have space to develop this view here but Monson's extended analyses (p137-177) of a performance by the Jaki Byard Quartet of *Bass-ment Blues* contains a number of phenomena which can be thought of in these terms. Parenthetically, this makes for a very

different impression of the relationship between jazz and popular tunes than that alleged by Adorno – a point I will return to.

Sayin' Something: Jazz as Conversation

Persistently, Monson's informants, like Berliner's (1994), think of jazz as a conversation. Musicologists, especially of a structuralist or poststructuralist variety, commonly employ linguistic metaphors or study methods for analysing music. Consider, for example, Nattiez' (1990) symptomatically entitled *Music and Discourse* or the various theoretical writings of Seeger (e.g. 1977). However, in Monson and Berliner's studies, it is *members* who are making such comparisons of the practical production of their music and conversation. Drummer Ralph Peterson (Monson, 1996 p78):

But you see what happens is, a lot of times when you get into a musical conversation one person in the group will state an idea or the beginning of an idea and another person will *complete* the idea or their interpretation of the same idea, how they hear it. So the conversation happens in fragments and comes from different parts, different voices.

Monson takes such remarks seriously and explores the sense in which jazz could be said to be conversationally organised. She cites Goodwin (1990, p6) whose remarks bare a similarity with Peterson's:

Participants in conversation have the job of providing next moves to ongoing talk which demonstrate what sense they make of that talk. It therefore is possible to see how group members themselves interpret the interaction they are engaged in.

In fact, Goodwin here is endorsing a common view in the field of Conversation Analysis (see the collection of foundational posthumously published writings: Sacks 1995). She draws attention to how conversation is locally organised as a series of 'next moves'. Indeed, two part 'adjacency pairs' (e.g. question-answer, request-compliance) can be found ubiquitously in conversational interaction. She observes that it is through their production of 'nexts' that participants display their understanding of the ongoing conversation. Conversation as a locally organised social production seems promising to compare with musical improvisation and, clearly, this is what Peterson is endorsing.

Monson presents a number of instances of interactional give and take in improvisation which are taken as conversational (p77-87). The interplay between soloist and accompanists, as well as the interplay within a rhythm section, can often be seen to be locally organised as first and second parts: spaces in a solo are filled with melodically oriented bass lines, triplets in a solo are echoed with triplet patterns in the bass, a drum roll leads into a new chorus, and so forth.

Sounding, Woofing, Playing the Dozens, Signifying

Monson takes this observation further. Not only does she find many elements of jazz improvisation to be conversationally organised, jazz relates to culturally specific forms of conversational interaction, in particular, those associated with African American formats of verbal duelling variably known as sounding, woofing and playing the dozens. Kochman

(1986) describes such formats (and others which he treats collectively using the commonly used African American term of ‘signifying’) as involving ‘indeterminate strategic ambiguity’ – whether an utterance is taken as a serious insult or a joke depends more on the receiver’s reaction than on any ascription of intentions to the sender. The maintenance of the interaction itself as a progression of challenges and responses is more to the point than inciting a fight. A “cool” or “hip” response to an insult will be one which responds with “poise and balance” (Monson 1996, p88, see also Goodwin 1990) rather than being unsettled or at a loss for words. It is precisely this kind of heightened challenge which Monson identifies in the exchanges in jazz. For her, there is a common African American cultural aesthetics at work.

This aesthetics sees a particular value in mimicry and imitation and in call-response formats (Floyd 1991). A linguistic example from Goodwin (1990) of ‘format tying’ is seen to have many musical analogues:

Billy, who has been teasing Martha about her hair, has just laughed.

Martha: I don’t know what you laughin’ at.

Billy: I know what I’m laughin’ at. Your head.

Of course, simply uttering ‘your head’ would have sufficed as a response to Martha. That Billy echoes the format of her immediately preceding turn heightens the tease.

Intermusicality

Monson continues the theme of linking musical features of jazz with African American cultural aesthetics in her treatment of what she calls ‘intermusicality’. This coinage of course parallels the term ‘intertextuality’ used particularly by literary theorists to discuss the relations between texts and, most especially, to pick out texts which themselves are made up of such relations through citation, allusion, lexical or stylistic mimicry, parody, pastiche or whatever. That jazz itself is, in part, about the relations between musics is the point here. Don Byron tells Monson (p104):

There’s irony *all over*, irony everywhere... It’s definitely that balance... between totally opposite aesthetics... the conflict between being serious and avant, and just playing swinging shit... a polar pulling between cleanliness and dirtiness, between knowing the rules very well and breaking them. There’s a certain kind of pull between opposite impulses that you... see in any good black anything... a certain kind of inventiveness outside of... what is acceptable. And I think that comes from being in the society in that role... just the fact that you’re not quite an accepted member of society gives you a certain distance from the way things usually go.

It is easy to relate such statements to well known themes in cultural theory. Byron’s metaphor of the ‘pull’ of opposite cultural tendencies is reminiscent of Bakhtin’s (1981) ideas of centripetal and centrifugal forces in cultural dialectics and, as Monson also notes, ideas of ironic intertextuality have been prominently discussed in African American literary aesthetics as well as relatable to the sociolinguistic notions of signifying discussed in the previous section. Monson sees these themes through in analyses of John Coltrane’s *My Favourite Things*, Roland Kirk’s *Rip, Rig and Panic* amongst other pieces.

Coltrane’s working of Rodgers and Hammerstein’s Broadway tune features many analysable

musical features by means of which the ironic effect is achieved. What are brief two bar interludes between instances of the main melody of the song (Raindrops on roses...) in the stage version become extended into eight bar vamps of a more harmonically complex nature. The 'B section' of the tune (When the dog bites...) is not heard until the very end of the performance and then in a truncated form which does not modulate as the original does into the relative major (Then I don't feel so bad...). Coltrane eschews then the cliché of modulating minor to major at the moment that, lyrically in the original, momentary misery is overcome. Soloing by Coltrane and McCoy Tyner takes place not over the chordal structure of the core melody, as might occur in much jazz improvisation based around a theatre tune, but over extensions of the vamps which are based on the more marginal interlude material. Furthermore, when Coltrane does play the main melody, he does so in a highly syncopated fashion quite unlike the very square depiction of the melody in the sheet music version which, evidently, a song plugger supplied to the Coltrane Quartet at a gig in 1960 when *The Sound of Music* had been in Broadway production for less than a year. Such syncopations – and the dense interlocking groove that the rest of the quartet provide – give the song a strong 'six feel' as opposed to the straight waltz time of the original. Even so a residual waltz feel is present, something which would have been heard as most unusual to jazz audiences of the time.

A vast array of musical features in the Coltrane Quartet's version can be seen to be playing ironically with the rigidities of a composed melody for the theatre. Melodic, harmonic and formal features are all inverted in their significance as an optimistic Broadway tune becomes a vehicle for "brooding improvisation" (Monson 1996, p117).

Music, Culture and Conversation Revisited

There are many interesting features for the study of improvisation in Monson's (1996) and Berliner's (1994) ambitious treatments of jazz. Of particular interest is how both authors try to trace the connections between the music, the fact that it is an improvised music, and its cultural context. In Monson's case, this includes some attempts to show that the music is 'enculturated' in its very texture: melodic, harmonic, rhythmic and formal elements are related to the specific situation of jazz as an (especially, if not uniquely) African American cultural production. These demonstrations involve, as we have discussed, a focus on intermusicality and a specific understanding of African American conversational practices. While jazz, its musicological analysis and cultural embeddedness are *per se* topics beyond the purview of the current work, I want to examine here the connections that can be made between improvisation and conversation in more depth. And this for a number of reasons. First, as this metaphorical association is so ubiquitous in performers' and listeners' discourse, we need to understand what is going on when the comparison is made. Second, seeing improvisation as conversation may give us an insight into the real time production of orderliness in improvised music. That is, it may help us link a characterisation of the situated activities of performers to the formal organisation of the music they produce. Third, the responsiveness of (good) conversational interaction is often taken as an aesthetic goal for (good) improvised musics. All of these matters will turn out to be important to my characterisation of what improvised electro-acoustic music might be.

Important to Monson's treatment of improvised jazz and conversation is to not merely note that members often make comparisons between the two but to give this an analytic status. She principally does this through Goodwin's work on the social organisation of talk in black children. However, a certain confusion can arise at this point. As noted above, Goodwin's remarks about the sequential organisation of conversation around 'nexts', how this offers in-built opportunities for recognising and displaying how the talk is understood, and how all this creates an intrinsic motivation for listening are ubiquitous features of conversation and are not just confined to specific formats of African American exchange. That is, the claim cannot be that it is by virtue of possessing core features of conversation that jazz is a specifically African American cultural production as these features are ubiquitous. The claim must be rather that to organise a music that way is a particularly African American thing to do. I think this claim must be taken very carefully as so much of jazz improvisation *does not* fit the model of conversation closely applied (and its close, rather than loose, application does seem to me to be required to licence convincing comparisons with sociolinguistic study of African American discourse).

Conversation is a turn taking affair, yet many of the organisational features of jazz concern the shaping of a player's contribution in the light of *concurrent* contributions from others. Jazz is after all, typically, a polyphonic music. In the terms of Sacks et al. conversations are locally managed a turn at a time. Yet much of jazz improvisation concerns the deployment of forms of organisation with a longer reach. A melody and its chordal harmonisation give players resources to organise their productions beyond what is immediately next. Perhaps the conversational metaphor could be rescued at this point by insisting on a flexible definition of what counts as a turn and hence when those moments of transition from current to next occur but this, of course, would be begging a specifically musical analysis of such phenomena which the conversational metaphor itself would no longer be guiding. A common treatment in the Conversation Analysis literature is to regard issues of turn allocation (who speaks when) and turn construction (what kind of speech action they are performing) as locally managed affairs in conversation whereas in 'rituals' turns are pre-allocated to specific speakers with a particular, known-in-advance, constructional formation. Hence, in the courtroom (Atkinson and Drew 1979), questions are pre-allocated to counsels and answers pre-allocated to witnesses. It is such pre-allocations which enable counsels and witnesses to interact as, precisely, counsels and witnesses. In jazz, or at least the kind studied by Monson, the pre-identification of musical roles for different instrumentalists again seems to me to be a matter in tension with any far reaching comparison with conversation (or with ritual for that matter as, I would want to claim, the characterisation of ritual we have been dealing with concerns the distribution of speakers to particular turn types and the notion of turn we have already argued is problematic, or at least awaits further explication, in musical contexts).

What are we make, then, of remarks like Peterson's which do make such comparisons? We must remind ourselves of the precise context in which the comparison is made. Peterson is pointing out *certain specific phenomena* and making a comparison with conversation on that basis. To be sure the swift completion of an utterance by a co-interactor is commonplace in conversation – indeed Leudar and Antaki (1988) is a study of just that. And this kind of latching and continuing is familiar in music too. In short, it is the observation of specific phenomena which occasion the comparison in Peterson's talk. As a matter of ethnographic method, I would want to respect this feature of Peterson's talk and regard his occasioned

production not as a (proto-)theory or analysis of or a metaphor for improvisation which should be extrapolated beyond accounting for the particular phenomena it is tailored for. To be sure, a jazz improvisation will contain locally produced features where a competent member – player or listener – can identify a current and a next. It will also contain features managed over different timescales, ones beyond an immediate responsiveness. As such the analysis of an improvisation would do well to treat this management of multiple musical times as a core topic. While locally produced examples of this-then-that, call-then-response, statement-then-variation when distributed across players attest to the social interactional organisation of improvisation, they do not exhaust its formal social interactionally engendered features.

I hope the reader does not think I have been labouring the point excessively, nor unjustifiably targeting Monson's ambitious work on jazz. My purpose is not to pillory Monson – though I do think it is too much to hinge an argument for the African American cultural specificity of jazz on an extrapolation of member's occasioned remarks and specific musical phenomena into a metaphor with substantive implications (though, in turn, it must be admitted that this is not Monson's only argument). My main purpose is rather to undercut the temptation to make immediate responsiveness an essential feature of an aesthetic of improvisation and valorising a sense of improvisation-as-conversation in order to do so. As we have seen, many of the world's musics are interactively produced in performance with varying degrees of pre-organisation. Not all of these can be properly typified as 'doing improvisation'. Even where improvisation is a member category, the texture of the music is not exhausted by formats which go this-then-that.

'Free' and 'Non-idiomatic' Improvisation

Monson's and Berliner's work on improvisation is principally confined to jazz musics in a recognisable tradition following from Coltrane, Charlie Parker and various others – a tradition very much alive in the music of the contemporary improvisors they study. It is a music of differentiated roles for instrumentalists, a music of solos and accompaniment, a rhythmic grooving music, a music of variations on borrowed, pre-composed or otherwise alluded to material, and so forth. Of course, all of these features have come to be optional or avoided in many forms of jazz from the mid-1960s onwards, as well as in improvised musics whose surface similarity to jazz may only lie in the choice of certain instruments.

As Dean (1992) emphasises, an equality of instrumental roles without any presumed relationship to soloing or accompaniment is notable in the music of AMM, Spontaneous Music Ensemble (SME), MEV, New Phonic Art, all of whom date from the late 1960s. For many commentators, the late works of Coltrane are jazz at the limits of post-bebop improvisation and at the beginning of new 'non-idiomatic' (to use Bailey's, 1992, term) forms. In the 1965 recording of Coltrane's *Ascension*, for example, the musicians were arranged in a circle, literally without any sense of a 'front line', to encourage their symmetrical attentiveness to each other and equal opportunities for participation. These recordings are characterised by dense improvised textures with only occasional recognisable soloing. For Dean (1992), these late Coltrane works announce a form of 'textural improvising' which is most prominent in the work of AMM. Over more than a thirty year

period, now, AMM have pursued a music in which the collective production of texture is a fundamental organising feature. On a number of occasions (e.g. in Childs and Hobbs 1982/1983), AMM percussionist Eddie Prévoist has described AMM's textures as 'laminar' – that is, made up in turn of a number of textural layers. Indeed, *Laminar* is the title of a three CD retrospective of AMM containing concert recordings from 1969, 1982 and 1994. The accompanying booklet recalls the weekly public rehearsals that AMM conducted in the 1960s in a highly reverberant rehearsal space. The use of sometimes extreme levels of amplification in a live room by musicians with a taste for texture naturally gave rise to a music where it can be unclear to performers and audience alike which instrument is the source of which contribution to the overall production. In a sleeve note to *Generative Themes* (1982), Prévoist remarks that the performers would commonly stop to listen to find out the source of a sound only to then realise that they were producing it themselves. In interview with Bailey (1992), Prévoist argues that this experience of a loss of one's identity within a collectively produced laminar texture can sometimes require a musician to 'differentiate' herself with a clearly legible gesture. It is the occurrence of such gestures which often precipitate a larger scale organisational change in the music as new materials are sought for continuing 'heuristic dialogue'.

It was improvising saxophonist Evan Parker who (Prévoist claims) first characterised AMM music as laminar. In doing this, he was making a contrast with the 'atomic' improvisation style of other ensembles in the late 1970s and early 1980s. Rather than organise a music around layered textures, atomic improvisations consist of microscopic elements arranged in relationship to each other. For example, some of the work of the SME, in which Parker played with John Stevens and others, can be characterised in this way. Indeed, in Stevens' (n.d.) book of improvisational exercises *Search and Reflect* great emphasis is played on the use of small sounds. Clicks, no matter what instrument they are realised with, are valued as a means by which musicians can immediately respond to the activity of others and do so with materials which will not overly dominate the sound. The click will leave maximal space for others to fill with their clicks. Using clicks and other atomic productions, then, a musician can maintain a balance between contributing and listening to others in a way which maximises mutual responsiveness. While Stevens regards the click as a limit case of the sounding duration, one which specially highlights the reciprocal relationship of sound to silence, he also writes from time to time as if sustained notes should be regarded as a sequence of instants – slurred clicks perhaps we can say. In the ongoing production of a sustained note, the musician is passing over a series of opportunities to stop playing. In this way, the rationale behind the click (responsiveness, leaving space for others) forms a baseline for assessing the utility of a sustained note. In a music of this sort, textural exploration through sustained sounds is likely to be rather exceptional.

In an interview, Martin Davidson (1997) asks Evan Parker:

Did you find playing with the SME restrictive at all? It sort of comes across that you are being restrained, shall we say.

EP: Are you sure that's not with the benefit of hindsight, looking at what came later? [what came later in Parker's work is discussed below – JMB]

MD: Maybe.

EP: I didn't feel particularly restrained. I felt a lot of what John was talking about, or the kind of method, such as there was one, was based on several quite simple rules, which is that if you can't hear somebody else you are playing too loud, and if what you are doing does not, at regular intervals, make reference to what you are hearing other people do, you might as well not be playing in the group. I mean I've put it in my own language, but those were maybe the two most important lessons that John wanted people to learn when they played with SME. And so there was what you can call a compositional aesthetic which required musicians to work with those two kind of rules or ideals in mind.

Dean (1992, p27-47) provides an analysis of the development of rhythm in jazz and non-idiomatic (or 'non-formulaic' in Dean's terminology) improvisation which can help us understand how a contrast between atomic and laminal styles could emerge. Dean traces a number of tendencies in the complexifying of rhythm since late-bebop: the superimposition of metres by aggregating pulses or their subdivisions into extrametric pulse groups; the use of changing and coexisting pulse speeds in metrical improvisation; and so forth. It is worth recalling Monson's observation at this point that the groove is a collectively produced phenomenon, requiring the intermeshing of different instrumentalists' contributions. Thus, these superimpositions and aggregations are not just rhythmic but also social interactional affairs – requiring ever more delicate and difficult practical coordination between players. *Something's got to give!* In particular, the status or very existence of a pulse needs to be re-valued. Dean (1992, p45):

... there seem to be two different stances, for both performer and listener. In the first, there is taken to be a continuing function of the same status as pulse (we can term it 'free pulse' or 'impulse' to distinguish it from fixed pulse) throughout most of the music. These impulses usually occur fairly close together in time – between twice and four times per second...

On the other hand, many musicians, including many of my European free improvising colleagues, admit to feeling rather slow impulses, of around one per 1.5 seconds, which are fairly regular, but do not quite qualify as pulses, and within which they place irregular groupings of subimpulses... The flexibility of approach this allows is useful for the improvisors in giving a sense of space units, which can be taken as appropriate for placing successively contrasting ideas, often one per space. On the other hand, the space units are not necessarily felt synchronously by the other musicians, in fact usually not... [which means] that a massive convergence on an accentuation point, out of a grossly divergent structure, is very rare... The consequence of this approach is that overall activity of a group free improvisation can readily become extremely dense, with events happening many times per second. There is no clear pressure to wait for the beginning of a subsequent impulse (one or more later) for the next action, unlike the situation in pulsed music. Indeed if as usual the musician is defining the impulse by the activity s/he performs within it, it may become rather difficult to continue to sense an impulse progression when not playing. This is perhaps one of the limitation of free impulsed playing.

What is interesting about Dean's analysis for our purposes is his attempt to fashion a three fold link up: between the maintenance of a pulse, certain forms of inter-musician coordination, and hearable musical forms. As the groove complexifies or loosens into the pulse, other forms of social coordination and musical organisation come into existence. But these in turn can be found problematic from time to time. A 'free pulse' might be hard to collectively sustain through improvisational playing in the absence of pre-composed material or a differentiation of musical responsibility. A slow unaccented impulse might lead to extremely dense textures without unexpected group convergences (indeed, achieving these too may require some pre-agreement or pre-composition, cf. my earlier remarks about such convergences in Fell's work). I read atomic and laminal styles of improvisation as further attempts to deal with this situation and this at the threshold of disappearance of the pulse.

Both are attempts to maintain characteristic forms of social organisation between players without relying on either pre-composition or the necessity of a mutually enfolding pulse. Dean (1992, p46) asks:

Do any improvisors work in what they feel to be an impulseless space?...

The most notable examples are the early work of AMM and, to a lesser extent, that of MEV... It seems particularly possible to achieve this state with electronic instruments, or at least with amplification of very soft sounds so that they can be sustained for very long periods...

It is interesting that there was a comparable involvement with long notes among composers in the early 1960s.. Thus Lamont [sic] Young's *Composition Number 7* of 1960 consists of an 'infinitely' sustained two-note chord... Many of these composers, like Oliveros and Young, were also improvisors, and it may perhaps be because of that experience of producing/performing music... that they developed this interest in long notes.

In more recent improvising, with the wide availability of synthesisers which can also sustain permanently, groups involving other instruments have also begun to be more able to perform such virtually impulseless music: for instance, AMM, Wired, New Phonic Art, and Gruppo Nuova Consonanza... This is an example of a clear influence of the availability of technology, but the wide development of circular breathing techniques among improvisors since Coltrane (for example, Evan Parker, saxophonist) shows that human devices can overcome the technical problems anyway, and this was a simultaneous evolution in the early 1970s.

I have quoted Dean at length because he makes some symptomatic connections between different forms of music and their organisation, and technology and instrumental technique. These are my core topics too. And this is how I'd formulate the questions these topics arise in response to. *In the fallout after the disappearance of the pulse, how are forms of socially organised improvised music making possible? How can something hang together when it is no longer the groove or its residues which is providing an intrinsic motivation for the players to attend to each other? What resources (other than those which are composed, borrowed, found in the groove or whatever) will enable us to achieve musics with multiple forms of organisation (current-and-next, longer reach)?*

One can play over drones and, of course, LaMonte Young has no monopoly on this. Drones are ubiquitous in the improvised musics of the world as a resource for giving pitch gravitations while allowing multiple temporalities to be constructed thereupon. A drone also enables a musician to test the resonances of a performance space. This interaction between drone, time and space is a feature of LaMonte Young's work just as much as it is of the Hindustani music discussed earlier.

One can breath in a circular fashion, something which in turn Evan Parker also has no monopoly over. However, Parker's specific reasons for extending his technique with circular breathing, double-tonguing and multiphonics are interesting to examine in depth. In particular, he suggests that they stem from an interest in developing strategies for solo playing after the experience of group improvisation of SME under Stevens' strictures (Parker 1992).

Realising that I was interested then in the challenge that solo playing represented I was aware that my approach had become overly concerned with the modulation of other musicians' input! I asked myself what were the longest units of material that could be incorporated into an improvisation? In answering this question I gradually developed the use of additive procedures for building patterns and used repetition/mutation procedures which have characterised much of my subsequent solo improvising. Two qualities have been remarked on consistently in the intervening period: comparisons with

electronically synthesised music and references to machines... Through the repetition of simple phrases which evolve by slow mutations (a note lost here, a note added there, a shift of accent, dynamic or tone colour) their apparent 'polyphonic' character can be manipulated to show the same material in different perspectives. The heard sound is monitored carefully and the small increments of change introduced to maintain or shift interest and the listeners' attention...

The challenge for me in solo improvising is to fill the acoustic space. Exploiting natural acoustic resonances the illusion of 'polyphony' can be enhanced. The activity of maintaining several layers of activity has more in common with the circus arts of juggling and acrobatics than with the soul searching of high art (or whatever it is supposed to be about)...

In testing my limits of duration I worked on two techniques which have given a particular character to what I now feel free to call my style. Using an up/down motion of the tongue, rather than the standard technique of tu-ku using throat attack, I developed a double tonguing which was faster and more flexible and capable of use over a wider dynamic range. This technique made rapid successions of notes of very short durations possible... To extend durations beyond a breath length I worked on circular breathing technique in which a small reserve of air in the cheeks is pushed through the instrument while the diaphragm is used to breath in through the nose... I worked on the reed's ability to sustain a lower pitch while articulating selected overtones combining the method for overtone selection... I worked on sustaining overtones and interjecting lower notes which is basically the same technique with different timing.

As elsewhere in this section we see an affinity in Parker's writing being articulated between ideas of machine music, a sense of the acoustic space and the deployment of specific techniques to accomplish an improvisation. Parker suggests that these techniques were developed to counter being "overly concerned with the modulation of other musician's input". Indeed he develops a new concern for "the longest units of material that could be incorporated into an improvisation" and "the illusion of 'polyphony'" – matters which could scarcely be further from Stevens' pedagogical emphasis on click music. Although these concerns and techniques to realise them were explored in the context of solo improvisations, Parker's recent duo and group work display the same general style. How the 'modulations' of the contributions of others occurs in this work is a matter worthy of detailed analysis. I can only hint at some topics for such research here. Most notably, I hear Parker timing the mutations he mentioned (their occurrence, their rate) in relation to the activity of co-performers. "A note lost here, a note added there, a shift of accent, dynamic or tone colour". In the group work, 'here', 'there' and the relevant shifts to make are coordinated with co-performers. In this way, Parker's techniques – born of solo improvisation – can find a characterful application in a collective setting. Of course, this can give rise to music which has a 'laminal' form as the continually mutated lines of Parker's saxophone layer with, for example, the electro-mechanically propelled guitar of Keith Rowe (e.g. on *Dark Rags*, where, incidentally, the wordplay of rags to raga is intended).

And so, at last, to the machine. We have seen musical machines (synthesisers, electro-mechanical interventions on sounding material etc.) presented as a means to engender impulseless music. Naturally, a drum machine or a sampler playing back an excerpted beat can accomplish the exact opposite too, even if that is used as the basis for a (pulsed) improvisation. When Parker notes that his own playing style is often compared with the productions of a machine, he particularly has in mind an algorithmic device which can generate a multiplicity of variations from a single musical 'seed':

Recent popularisation of the ideas of chaos theory means that most people are now familiar with fractal patterns and Mandelbrot figures. Without wishing to jump on a band wagon, the process

involved in the evolution of a phrase in this way of improvising has something in common with the equations that generate these patterns and figures where the output from one basically simple calculation is used as the input for the next calculation in an iterative process which by many repetitions finally generates a pattern or figure whose complexity is not foreseeable from the starting point.

The ever-same drone machine, the ever-same pulse machine, the ever-new phrase machine. Three musical machines. We can think of others. Musical machines are ubiquitous. But how exactly do these machines relate to the social organisation of improvised music making? How exactly might a machine stand in lieu of or enable the coordination of players otherwise achieved through other means – groove, pulse, raga, call-response, mimicry, search and reflect, layered texture, ecstasy? How on earth could a machine do or help with any of that?

Chapter 2

Improvising Machines

Introduction: Machine Music

The previous chapter surveyed various standpoints on questions of improvisation. During the course of this I offered an orientation to such matters. We should resist abstract theoretical oppositions (e.g. ones which set improvisation in contrast to composition) in favour of an empirically informed approach which examines what improvisation might mean practically as an indigenous category for members. We should resist the temptation to read a trans-cultural notion of improvisation into all the world's musics. If improvisation is our concern, we should prioritise examination of the concrete practices of those who do nominate themselves as improvisors. This led to a particular treatment of jazz as a socially organised musical practice and a discussion of various methods in so-called 'free' or 'non-idiomatic' improvisation. I closed the chapter by raising the question of the potential roles that machines might play in the real-time production of improvised musics.

This chapter elaborates on matters to with musical machines, while continuing the empirical orientation that my treatment of foundational research topics has. I focus in particular on improvised electro-acoustic music and present an extended participant-observational study of my own activity as an improviser in collaboration with others. On the basis of this work, I isolate a number of analytic issues and offer an extrapolation of these matters into a sketch of an aesthetic for improvised electro-acoustic music. In the chapter following this one, these issues and their allied aesthetic combine to inform the design of technologies for improvisation – in particular, computer-based technologies.

Improvised electro-acoustic music may seem to be on the margins of musicological interest (better to examine Wagner's anti-Semitism), not to mention of limited audience interest (better to go clubbing). But my argument for focussing on this music is not based on such criteria. Rather, improvised electro-acoustic music is a *prima facie* perspicuous instantiation of the topics I wish to pursue. *Electro-acoustic music is indigenously a machine music*. Its production has always been bound up with particular uses of particular machines. Chadabe's (1997) historical survey and interview-based study is particularly informative in this regard. The establishment of post-war electronic music studios – be they in universities, radio stations or privately owned – was a matter of acquiring specific sound recording, manipulation and reproduction technologies and experimenting with their use. Whether those experimentations were done in the name of 'elektronische Musik' in Köln, or 'musique concrète' in Paris, for the liberation of sound from human intentionality in John Cage's New York loft, or under the cover of telephony research at Bell Labs, machines (tape recorders, synthesisers, computers amongst many fascinating alternatives) were repositioned as central to musical production.

Many influential theoretical texts in the literature of electro-acoustic music re-affirm and endorse this relationship and feel the tie between music and machines to be most intimate in the case of the computer. For Xenakis (1971/1992, and see the interview in Chadabe, p279, where Xenakis discusses his relationship with IBM-France in the early 1960s), the computer is a calculating machine which enables a mass of stochastic reckonings to be done swiftly. Wishart (1985/1996) reveals that his encounter with computers at IRCAM in Paris in the early 1980s presented him with "an instrument... through which I could realise some of the concepts of musical transformation I had been dreaming of for some years" (p3). Indeed, many musicians, composers and researchers would regard their field as, precisely, 'computer music' – see the collections and textbooks associated with Roads (1989, 1996, 2002; Roads and Strawn, 1985), not to mention the MIT Press' Computer Music Journal or the yearly International Computer Music Conferences (ICMC) and the professional body which curates them (the International Computer Music Association, ICMA). For some time, music has been a prominent topic in artificial intelligence, and many musicians and researchers look to AI for computational techniques which can be used compositionally, analytic tools for musicological purposes or metaphors for the musical mind – Balaban et al. (1992) is but one collection. The association of electronic music with computing technology is seen to have profound cultural implications by many commentators – Attali (1985), Taylor (2001) and the collection edited by Emmerson (2000a) give us a spread of examples.

We can of course debate the precise relationship between dreams, mathematics and musical practice, and the typification of the computer as an instrument, calculating machine, a source of artificial intelligence or cyber-culture, or as the proper object for disciplinary definition or professional allegiance. But I have already laboured the point – and this is to establish electro-acoustic music as a machine music *par excellence*.

Incidents

To study improvised electro-acoustic music empirically, then, should illuminate our concerns for improvisation in a machine world. I have practiced as an improviser in this domain for

nearly four years during which I have performed in a series of concerts in solo, duo, trio and other formats. From the start, I have been working with computing technologies and sound synthesis. Throughout, I have reflected on my practice, kept field notes and assembled a corpus of research materials (documents, sound recordings, concert videos) appropriate to the conduct of participation-observation enquiry with an ethnographic flavour. In tandem with performing, I have developed specific computer-based applications as well as various manual and electro-mechanical devices to play with before the public. This design and development work has come to have a degree of systematicity based on reflective performance experience. I give technical details of my constructional work in the next chapter with overviews and clues to its identity in this. The reader should realise, though, that this is for convenience of exposition as performance, reflection and design were concurrent – each performance being an opportunity for the ‘testing’ of provisional designs and examining their quality. I organise the presentation of my material chronologically, around particular concerts in sequence and informative incidents within them. I do not consider all of my concert or performance work here but I do enough, I hope, to show how the design approach of the next chapter was formed, as well as giving the reader an impression of what it was like to live through it all.

Working Things Up To Leave Them Alone: Ipswich

Just after Easter 1999, I organised an event in Ipswich which combined a number of interactive installations and featured a continuous twelve hour electro-acoustic improvisation by Sten-Olof Hellström (SOH) and myself. This was my first performance of any sort for a number of years and, for personal purposes, I proposed an event which was in some ways deliberately challenge-ful, in other ways relaxed. Admission was free – indeed, each visitor was entitled to take home a commemorative tin of baked beans (my local grocer gave me a good price on an order of one hundred) – and the day was organised without any ‘sessions’ to further encourage people to come and go as they pleased. Some of the installations were preliminary versions of interactive pieces developed within a European Union funded project I was working on. Their prototype status, the free admission, the lack of a publicised internal organisation of the event, and its sheer length were an attempt to establish a notion of ‘working in public’ where good things might be done but nobody was counting on it. The venue did not have a town centre location and Ipswich is not known for its audience of electro-acoustic or improvised music fans. Indeed, the local paper covered the event as being unique in the cultural history of the town. All our strategies for the event – free of charge, come and go, yet ambitious with an international dimension – were also geared towards testing the locality to see if an audience could be found or created.

Access to the building was secured from 0900, the earliest possible time. We had to vacate the premises by 2210. To deal with this we regarded rigging and de-rigging as part of the performance itself. To establish the twelve hour duration, an oscillator was to be heard from 1000 and enough equipment left rigged up to support it again at 2200 whereupon it would be cut to silence. But what was to be done in between?

We decided to extend the principle of our audience having the latitude to come and go into our own orientations to the music and its production. We too would need to come and go – to the toilet, for example. We would take breaks for food and drink. We would play solo, duo

and in relationship to anything a visitor might do at the installation which featured interactive sound. We each had a variety of things we could do. In the accompanying leaflet/press release, I presented the performers as moving between ‘stations’ ranged around the performance space. I had a *Multiplied Breath* station (where multiple algorithmically generated lines of control data could be generated from a stream of performer activity at an electronic wind controller and distributed to a number of synthesis engines), an *Aether Capture* station (where live sound from two radios could be processed), and three paces away was *The Truth Table* (where an overhead video camera analysed the relative movement of objects placed on it to derive control data for sound synthesis). Each of these installations could run autonomously. In principle (in fact the video analysis software didn’t work correctly), an object could be left on the table and algorithmically derived musical material would issue forth. The radios could be left on or between stations and allowed to drift, while their output was, in turn, variably processed. The synthesis work was done so that knob control was available if the wind controller was put down or the player ran out of puff, and again algorithmically derived material would be generated. In this way, I could come and go too. I could vary my relationship to the different parts of the room visiting its ‘stations’ around the perimeter, a seating area in the middle. I could engage with one, while leaving another to work autonomously. I could provide a texture for SOH to play over and then take a comfort break. I could offer a visitor a tin of baked beans without having to stop the music to do so. The twelve hour event became manageable with these strategies and design principles: it was not an endurance test.

The point here is to emphasise how various practical details of the event and what it required of its performers were worked through to assemble a manageable environment for extended improvised electro-acoustic music. Our synthesisers – and the musical algorithms we had running on laptops to generate material without continual human intervention – partook in this management of practicalities to create a particular kind of performer: one who can come and go. Put another way, performer activity could now be patterned according to its variable engagement with the machines which were deployed. Amongst other things, we could work up sounds into a state where we could leave them alone. At the end of the day, I returned home with 68 tins of baked beans.

Enacting Three Swooshes: Siena

Siena, unlike Ipswich, is not my hometown. I had to travel by air to Florence, then by coach, finally on foot up the hill of the old city, taking my equipment for the performance in my luggage, rather than conveying it in a borrowed van. The performance with SOH, under our occasional name of *Critical*, was part of a lecture-demonstration session within a three day conference in October 1999 at the Santa Maria della Scala Museum organised by the European Union to exhibit and review part of its IT research programme. We shared the session with, amongst others, a group of researchers working on an ultrasound sensor to help people with disabilities play music. We had a 30 minute slot to play our music and for me to deliver a lecture about it and the interaction technologies we were using to realise it – a very different working context from ‘the Ipswich 12’ event.

Accordingly, we agreed to travel light and set ourselves quite rigorous equipment constraints.

The performance would be realised with (each) a synthesiser, a touchpad and a laptop computer. Both of us were running software applications on the laptops which processed the MIDI from the touchpads, generating multiple streams of data to control quite complex sound synthesis models. Principles for making the transformation from (few) input data streams to (many) output data streams made up the topic of the lecture. SOH and I had different ways for doing this (for more details of my strategies, see Chapter 3). The minimal equipment set-up was intended to facilitate our performance as a legible technical demonstration: it would be this hand on that touchpad transformed by that algorithm which would make that music.

To keep to time and to reassure ourselves, I drew on a scrap of paper an ‘intensity envelope’ as a ‘score’ for the performance. Intensity was to rise and fall in three iterations. Each iteration was shorter than the previous one and each falling was progressively more abrupt – the final one being a cut to nothing to close the performance. We agreed to realise this structure over a period of about 12 minutes. I placed the paper with the triple swoosh on it on the table between SOH and myself. For my benefit, I added a series of letters along the bottom to denote a potential ordering of synthesis programs which could fit in. Pressing the letter on the laptop keyboard would load the sound in the synthesiser. I had two restful ambiances selected for the first two troughs in intensity and an especially raucous program lined up for the finale. I also knew which sound I would start with.

We were working, then, with a notion of improvisation within an external structure. The moment by moment coordination of our sounds was left up to us to locally accomplish. The exact moments in which new sounds would appear would also need to be locally determined. The serial order was approximately fixed and special functions were associated with some of the sounds we would use. Knowing this, hearing a characteristic sound, and having a sense of the relative ongoing intensity, we would be able to determine where each other thought he was within the envelope, as well as be able to play in a manner to provide this information to the other: if you are playing that sound like that and I am doing such and such, then we must be here.

As we start, it soon becomes clear that the reverberant 16th century room is deeply influencing our impact and conduct. The overall sound seems pleasantly powerful, SOH’s and my sounds seem partially folded into each other, and the room is providing a form of ubiquitous monitoring for us. While we may be losing some detail in the reflections, the room is making it easy for us to play. We start well, making no obvious mistakes or suffering from hesitancy. Perhaps to help us keep on track and not get lost in the character of the room, I find myself exaggerating the laptop keypresses to signal to SOH that I am making orderly progress. At the end of the first (long) swoosh, I point to the corresponding curve on the piece of paper, catch SOH’s eye and notice him nod. We are in agreement. We are at the same spot in our enactment of the structure.

To run up the final hill, I need to load sound Q. By error in my preparation, I had programmed the sound to load on a default of maximum volume. To get the sound fit for purpose, it has to be cut immediately on loading. This requires my left hand to reach over to the Q on the laptop, itself placed to my left, while I disengage my right hand from the touchpad to grasp a knob on the front panel of the synthesiser, placed to my right. My body takes up a noticeable sprawl over the equipment before me. SOH glances over, seeing my

readiness. I bring down my finger onto the Q and turn the knob down with a whole arm twist which I continue into a whole body turn as I disengage from both knob and key. SOH brings in a low quiet sound precisely as I find myself turned to face him. We are in the valley before the finale. I turn back to the synthesiser front panel and gradually swell sound Q into the intense texture it is required to be. At maximum, I hold my right hand over the volume control and bring in my left to introduce a high frequency boost and then a modulation to the filtering. As I turn the knobs, I gradually lean towards the front panel. When the modulation is on the edge of excess, I lean back and face SOH. He looks over. I move my left hand away from the panel, leaving my right poised on the volume knob. I arch myself backwards a little further and then project my torso down while turning the knob anticlockwise. I continue my hand through and away from the panel. SOH has also stopped playing. As the considerable reverberation dies down, we relax together, face the audience and gently bow. We have finished. There is generous applause as I adjust myself to deliver a technical lecture.

2.2.2.2.0 – Too Much, Too Little and Deaf in One Ear: Stockholm and Norwich

Pleased with the outcome of the Siena event, SOH and I performed a series of concerts with the set-up I came to call with a degree of self-deprecation ‘Version 2.2.2.2.0’ – two men, two laptops, two touchpads, two synthesisers, no ideas. However, this relatively minimal set-up (for the moment neither of us were using the laptops to process digital audio) came to have various performance dilemmas associated with it. For example, SOH and I were using identical Nord Modular synthesisers and, at the time, had a commonality of interest in synthesis techniques which drew on techniques of physical modelling (extensive feedback between synthesis modules, non-linearities of response, and so forth). This could yield situations where it was unclear to both audience and performers who was producing which sound. We could exaggerate various gestures to make clear when we were engaging or disengaging with our sounds and hence allow ourselves and the audience to diagnose the situation. Sometimes, as at Siena, this seemed natural. Othertimes, it was more forced – as if the performer was stepping outside of the music to investigate or explain what was going on. Since the Ipswich 12 event, I had been designing performance software and synthesis patches so that music could be produced with machine autonomy. That is, the continuation of sound did not require continuous exertions from human performers. I could stand back and the machines would do their stuff. I could also intervene and change parameterisations. However, this machine autonomy and flexibility of human engagement could sometimes come at a price of the legibility of gesture both for audience and co-performer.

A concert in November 1999 at Fylkingen in Stockholm revealed some other problematic features of Version 2.2.2.2.0. The event was conceived as a continuous performance across multiple contributors. Some contributions were live, some on tape. Some of the live work was improvised, some not. The first part involved a projected film with a recorded electro-acoustic sound track. As the soundtrack finished, I faded in a slowly varying quite gentle background texture. This accompanied the raising of the (large) projection screen. The soundtrack composer called my sound ‘elevator music’ as a pun on its role to cover the elevation of the screen and as an ironic comment on its restful nature. With the screen fully raised, we were to play for 10 to 12 minutes, ending with a different but equally recognisable gentle texture. This

would be the cue for a person at the mixer desk to start the following contribution – a tape composition the beginning of which worked well with the sound I had selected for the transition. These fixed starting and end points and the limited time available structured our performance just as surely as the marks on paper had at Siena. We did not wish to play with complete disregard for what we followed and for what was to come. We wanted the transition sounds to become part of our musical material and not just serve a mere bridging function. We felt ourselves again enacting a pre-defined structure – a kind of ‘arch’ composition emerged.

The arch was not especially elegant however. It seemed to me that SOH was not playing very well. When I gave him space and offered him material to respond to, he didn’t seem to be working with the timeliness I was expecting. Assuming he was having a bad day and was feeling extremely reticent, I felt I had to carry the performance and played more and with more intensity than I might normally. Afterwards, SOH was unhappy at my overplaying. I explained what I was doing but SOH defended his contribution. On further investigation, it transpired that a cable carrying SOH into my monitor mix had failed. SOH by contrast had a full monitor mix. I was only hearing him from his monitor and through the back of the PA speakers, hence my impression of dullness and tardiness in his contribution. Of course, once we diagnosed this problem afterwards with me listening to a static mix from SOH’s side of the stage, then mine, it was obvious that the sound quality at my spot was anomalous. Why did I not realise this in performance? Then, I was not able to do A/B comparisons. I did not want to stop the performance, test things, confer with SOH, and then start again. Any diagnostic activity I was to engage in would have to be done in the moment. Any tests I needed to perform would be best done in the music by musical means. Perhaps, I could have made a pained expression and mouthed a phrase across the stage, but better to sort things out internally, through sound, musical gesture and on the spot reasoning. I began to feel that the constraints of Version 2.2.2.2.0 did not give me the capability to do that. The set-up didn’t seem to be fail-safe. It didn’t offer me enough resources to flexibly vary my contribution, distancing it from SOH’s if needs be, or to diagnose problems if they were occurring. Not surprisingly, at Fylkingen, several audience members complained that our contribution lacked dynamic variation and had few clear instances of interplay between the performers.

A concert at the University of East Anglia in February 2000 gave the first clear opportunity to explore an alternative approach. I prepared a variety of different resources for this event. The Version 2.2.2.2.0 set-up was retained but as just one component. In addition, I revived the radio processing ideas from the Ipswich 12. Most notably, I had a first effort at an algorithmic sound mixing application which would take sound files from hard disk and process and combine them in various ways under interactive control from a MIDI fader box. I also brought along two small Theremins. This was all held together by, on the one hand, a good quality DJ-style mixer I had just acquired and, on the other, an artistic concept. The performance was entitled *Channelling* and would be an exploration of various interpretations of this notion. The process by which channels are gradually created through geological erosion, the channels of broadcast media and sound mixing, and ‘channelling’ as used by those formerly known as clairvoyants – these were all senses which we alluded to. Or so the programme notes would have it. I envisaged a three part structure of about 30 minutes overall duration. The first would contain Version 2.2.2.2.0-like activities. The second would contain my live radio processing and Theremin manipulation. The third would be based around a

recording of the first part (made with a stereo microphone and a minidisc recorder resting on the table alongside all the rest of my equipment). The performance was to close acoustically as a 78 of Artie Shaw's band would play unamplified on an antique wind-up gramophone.

The difficulties with this performance were legion. I completed a version of the algorithmic mixing software only in the small hours of the night before. I was tired and working with untested apparatus. Our rehearsal-soundcheck was marred by a moment where an extremely loud burst of sound came from SOH's laptop. Everyone in the concert room thereafter was extremely short-tempered and impatient when they weren't feeling shell-shocked. SOH struggled with software problems throughout rehearsal as an installation was eventually diagnosed as corrupted. In performance, I forgot to switch the minidisc recorder on, so the third part lost its formula. While we started well (Version 2.2.2.2.0 was familiar territory) and the processed radio sounded enigmatic, I had no fluency with any of the newly developed elements of my performance set-up and, above all, no fluency in moving between its different components. Having faded the radios in and worked with them for a while, I forgot to switch on and raise the levels of the Theremins. Silent gestures in thin air confusingly followed until the mistake was noticed. My use of the DJ mixer was tentative. The algorithmic mixing software seemed to fall into one of two 'degenerative states' rather too often. It would either loop in 'scratch mix' style or deliver broadband noisy textures. The former seemed an objectionable cliché, while the latter was hard musically to interact with or add to as it already offered a full sound. We were facing the audience in the midst of a multi-speaker sound environment which some of the other pieces in the concert were to be diffused around. This set up an uneasy compromise between the needs of performer-monitoring and giving the audience the immersive sonic experience which much electro-acoustic music is concerned to engender and UEA concertgoers would tend to expect. From our listening position as performers, our most audible loudspeakers were a mid-rangey pair placed far to our rear.

Phenomenologically, I begin to feel a four way dislocation: between my embodied activity at the equipment (why am I having no effects?), the sound that is in the concert hall (where is this coming from?), my attempts to actively and consequentially listen to it (what am I hearing?), while maintaining interaction with SOH (how can I respond?). I might thrash my limbs with no sonic consequence. There may be sound but I can't listen within it for details which might shape my activity. In the face of these problems, I am attending to my equipment, my hands and my ears. I am trying to work it all out. I am rarely interacting with SOH. I am rarely improvising music. I am adrift in a world of problems with an ineffective body and resistive machines. I may be pushing hard but all is viscous. I feel thick-headed as if suffering from a bad cold.

I am relieved to hear Artie Shaw strike up the band. A 78 has never sounded clearer to me and, as I wind the handle after the second chorus to ensure Artie and the boys will make it to the end, the gramophone seems a paradigm of musical interactivity. Perhaps this contrast is felt by the audience too as surprisingly strong applause follows. But it is Artie who should be taking the credit: we made him sound even better than he actually was.

Composition Machines and Contact Microphones: London

While there might be performance dilemmas associated with a paucity of resources – especially if those strongly overlap with those of a co-performer, the *Channelling* concert demonstrates difficulties which arise by simply adding more to the repertoire. If those resources can not be fluently worked with, life is no easier. Indeed, other problems might creep in: lack of preparation or testing, omission errors, turgidity, forgetfulness. Naturally, there is nothing in this list which couldn't be rectified by hard work. But hard work of what sort, in what context?

A change of format perhaps. After a lecture-recital SOH and I had given at the Royal Music Academy's Postgraduate Conference at Huddersfield in January 2000, I met Simon Vincent (SV) – a former colleague of SOH's. He was very complementary about our duo performance (Version 2.2.2.2.0-style). In conversation, we shared a number of points of unease over the electro-acoustic concert programme at the Conference and decided to found a trio out of shared grievances if nothing else. This, the Zapruda Trio (Z3), has been a major component of my performance and recording activities since. A series of concerts by Z3 over the summer of 2000 gave respite from solo or duo performance and space for easier experimentation with performance arrangements and principles.

The first of these was at the Smallfish record shop in Old Street, London in June. This shop specialises in electronica and the more experimental ends of dance music, as well as offering a number of titles of electro-acoustic music. It holds an occasional series of concerts in the shop on Thursday evenings, where performers and DJs use the sales counter for their gear and a small audience fills the small shop, sipping beer purchased from a nearby off-licence – a rather different setting from the academic concert hall at UEA or the site of a mediaeval hospital in Northern Italy. The concerts at Smallfish are set up immediately the shop closes and, as soon as an act is ready, it performs for 30 to 45 minutes. When finished, the next one sets up and performs, and so on. If the intended tight schedule is kept to, three acts can appear and the event is done before local residents feel entitled to complain. Knowing these contingencies in advance disciplined me to a simpler and more organised set-up than in *Channelling*.

To simplify the set-up in a principled way, I decided to use the three stereo channels of the DJ mixer to not just bring together three sound sources but to assemble three different kinds of interactivity. Algorithmically generated material based on digital audio source files was played back from the laptop onto Channel 3. As before, the software was designed so that it could play autonomously. Here, though, the parameterisations of the algorithms would also drift over time to generate material in different ways and introduce a further level of variation. The intent was to build a 'composition machine' which could create material live but in a relatively unsupervised way. Periodically, I would intervene in the behaviour of the machine, load new sound files, or set new ranges for the parameters to drift in, et cetera (this software is described in Chapter 3). By contrast on Channel 1 was the sound of two processed contact microphones. These were left free to be held, for example, in a cupped hand while the other applied stimulation from a children's toy vibrating pen (normally used to produce wobbly writing for comic effect). While Channel 3 could make a contribution without continual interaction or intervention, Channel 1 has the opposite character: the contact mikes in this

configuration would only sound with manual attention. The Nord Modular's synthesised audio was hooked up to Channel 2 and its productions combined elements of the algorithmic and the manual. The synthesiser was played by a Yamaha WX11 wind controller and an MFC10 MIDI foot controller via a software application on the laptop which rescaled and analysed the MIDI input in various ways. The wind and foot controllers directly generated sound from one patch on the synthesiser. Up to three other streams of data were machine generated for interpretation by three further synthesis patches. The control data from the MIDI devices or generated in software could also be overridden by control from the knobs on the synthesiser's front panel. The whole arrangement was designed so that from left to right across the surface of the DJ mixer, that is, from Channel 1 through 2 to 3, we move from direct interactivity to machine mediation.

As a further embellishment, I played back some stereo recordings from minidisc using a standard portable player. These were of soundscape material or presented acoustic improvisations I had done in a characteristic sound environment. The performance-time interaction I had with the minidisc player was of the same order as with the composition machine (intervention and selection) but without the ability to reparameterise to shape playback – this was a standard portable minidisc player with no 'circuit bending'. Accordingly, it resided also on Channel 3 with the mixer's source selection switch enabling me to toggle between the laptop's audio and the minidisc player.

The mixer links Channels 2 and 3 on a cross-fader. This made it possible to control mixes between the two sources capable of autonomous sound production – the hand on the cross-fader not required for manual control elsewhere. The design of the mixer and the topography of interactivity I had decided upon facilitated ready transitions between dual-handed, single-handed and hands-free operation of the equipment before me. This systematicity of design was a step towards addressing the fluency problems encountered in *Channelling*. Now, there were varied sound sources and interactive resources but organisedly so. Particular transitions, contrasts and interrelations were provided for, and it all fitted into a suitcase.

Preparing this performance set-up made the concert at Smallfish rather more pleasurable and effective than *Channelling* even though it proved impossible to contact SV to discuss the concert planfully before he met me at Liverpool Street railway station with less than an hour to go, and the shop's sound system and huddled performance space were less than ideal. A more fluently manipulable set-up enabled me to work on the music and less on wondering what was going on. SV brought new material to the mix – especially percussive sounds and suspended textures. We could flexibly configure around various duo sub-combinations to bring out commonalities or contrasts in material, while allowing the third party to prepare what might come next. We could buy each other time more readily than in Version 2.2.2.2.0. My local set-up also allowed the buying of time without necessarily suspending contribution. The cross-fader could be swung hard right and Channel 3 would issue forth autonomously while new patches were loaded into the synthesiser. I could re-enter the action, intervening on the composition machine, moving the cross-fader while picking up the wind controller. If any of the machines failed me, there were always the contact mikes to knock against one another. Under one of SV's tension-filled suspended textures, I could roll the mikes around in the palm of my left hand, while my right hand performed various debugging operations.

Afterwards SOH revealed that he had adopted a particular strategy for the concert in case the trio had not gelled. We had not rehearsed, we had not discussed the event with SV, and, from the outside, I was still showing signs of the over-indulgence which had served us so badly in *Channelling*. SOH had recorded some improvised material and lightly edited it into a 20 minute piece. Unlike my minidisc recordings, he prepared various methods for interactively shaping the playback of the material beyond just starting, stopping and amplitude adjustment. The recorded improvisation could be timestretched, resonant filtered, reverberated, expanded and gated to chop it up, and the playback point could be dynamically reset. All this was accomplished live with commercial software running on a laptop. What is of interest is how the selection of treatments for the recorded material relates to the interactional situation of group improvisation. The resonant filtering allowed the prepared material to occupy parts of the spectrum which were relatively unoccupied by the other performers. If SV and I were creating too tight a spatial image, reverberated playback might compensate or encourage us to loosen up. If SV and I were already creating a dense texture, expanded and gated playback would contrast with punctate events. The recorded improvisation was prepared with enough internal variety to permit different kinds of sound to be found by merely varying the playback point. In addition, its overall shape might encourage SV and I to work in an orderly way if needs be. Unbeknownst to SV and me, SOH had prepared material which could flexibly help to structure our performance 'from within' – in contrast to any scribbles on paper or other performance plan which might offer a structure 'from without'. As it turned out, SOH did not need to supervise the performance in this way. The trio worked adequately without it. He could manipulate the pre-recorded material for other ends.

Mister Big Gesture's Injury and Comeuppance: London

Z3 were due to play three further concerts in London over the summer and early autumn of 2000. For the first of this ad hoc series, SOH couldn't travel from his native Sweden. I made the shorter trip from Suffolk and joined SV for an interim duo at the Red Rose Club as part of an event we were promoting ourselves. In the mean time, we had acquired a desk recording of the Smallfish concert and released it as a CD on SV's vision-of-sound label with primary distribution being through Smallfish's shop and web site. Listening a number of times to the recording convinced me of the value of the physically manipulable resources I had included in my set-up. I brought the contact mikes again to Red Rose and was determined to bring a further degree of direct physicality to the performance whether this was to be accomplished using the mikes or acoustically and unamplified. I was also impressed by SV's percussive sounds on the CD. He could cut through density with them if needs be. On other occasions they would add to the mix without taking space away from co-performers. In certain contexts, a percussive or impactful contribution would precipitate change in the music as it would seem to announce the closure of what had gone before. I prepared a number of sounds for triggering with the wind controller which might have a similar role, perhaps by analogy with the clicks and pops wind players are able to extend their technique with. I also made three patches which synthesised explosions. SV and I played a rowdy 20 minutes in a programme containing a number of other performances and pieces on tape.

All performers combined for a final open-ended session. During this, I withdrew from the

stage area and contributed by playing percussively on a plastic ashtray at one of the tables in the audience area. After a while, it broke in my hand but this gave me musical variation: I could now rub the shards of brittle plastic together. These sounds – with direct physical engagement at their source and inhabiting a quite different acoustic space than what was carried by the loudspeakers – proved most useful. The acoustic sounds were scaled to the bodily force I applied to them, and made for a refreshing contrast to the extremes of algorithmic mediation I had tried to find a home in before. Of course they were, of course they did. I was rediscovering a traditional instrumental technique (banging and scraping) and a concomitant phenomenology of playing (making music, not interpreting interfaces). I was not trudging through treacle. I was however bleeding very heavily from a deep cut on my left hand.

In a concert with Z3 at City University in October 2000 I wanted to consolidate this mixture of physical manipulation and algorithmic mediation – and with less blood being spilled. In the interim, I had been experimenting with electric guitar – a Gibson Les Paul copy I had bought from a junk shop many years ago. I investigated one-handed playing techniques – so that the other could control various treatments or attend to other business at the synthesiser or DJ mixer. I also wished the guitar to serve the role I had previously assigned to contact mikes and ashtrays: percussion. Accordingly, I slackened most of the strings, some to the point of resting on the pickups where they pleasantly popped, and dampened them. I reordered the strings so that movement between adjacent strings or sets of three would maximise the variation of up-down pitch trajectories that were to be had with single-handed use without coordinated plucking and fretwork. In all these respects, I was optimising the guitar for default operation with rubbed, scraped or struck interaction from one hand, or to be repeatedly percussed by a hand-held battery operated fan or (again) a vibrating pen toy. In this configuration, a continuous, recognisable guitar tone could be achieved – but only if both hands were brought to bear, one to pull the string into tension. Equally, I used a guitar pedal effects unit to enable more recognisable guitar instrumental sounds (e.g. with distortion or feedback) to be acquired if needs be. Some other patches were programmed into the unit to make the guitar have common ground with an electronic soundworld (e.g. ring modulation). I wanted a device with a variable instrumental identity and which could be simultaneously inter-operated with the machines requiring parameters to be set, sound files to be selected or a cross-fader to be flipped. This suitably ‘Hacked Axe’ (as I came to refer to it) was on Channel 1, the home for direct manipulables, with the Nord Modular on Channel 2. Channel 3 played an improved composition machine alongside a very simple application which could switch on up to two simultaneous loops for static and suspended textures. Again, soundscape recordings and allied material on minidisc could be switched in if required.

Z3 were to play two short sets, each about 15 minutes, one in each half of the concert programme. We agreed to make a contrast between the two – the first to be more gentle than the second. Our first improvisation was extremely tentative. I was reserving my more impactful, percussive work for the second half, confining myself to making pops and clicks on the guitar and low level sustained textures. However, this was a crude enactment of the first half-second half contrast and overly constrained my repertoire to achieve even gentle things. SV and SOH were not managing any better. On hearing a desk recording some weeks after the concert, I characterised our first half improvisation as in the degenerative state of ‘FIFO’ – for ‘first in, first out’ (by allusion to mathematical queuing theory, in musical terms

a simplistic temporal organisation) or ‘fade in, fade out’ (new material being introduced most tentatively and withdrawn predictably). No obvious mistakes were made. But, on the other hand, no real musical benefits were achieved and no interesting interactivity between performers accomplished.

Although audience applause was polite, we were most dissatisfied with the first half. We still had a chance to remedy things though. I decided in my own playing to negate as much of the character of the first half as possible. And from the start. Without warning, I brought my hand down extremely hard on the guitar and processed the sound with a very raucous distortion effect. As the sound slowly subsided, SV inserted a CD into the drive on his laptop. My noise terrorism then traded musical time with, of all things, *The Girl from Ipanema*. I reasserted the guitar noise blast. SV reasserted the rights of easy listening fans. Naturally, SV and I were laughing – as were many in the audience. Neither of us gave way. Eventually, SOH essayed a synthesised texture to which SV and I accommodated our sounds – both of us by progressively fragmenting what we had just presented so nakedly into more malleable and responsive material.

We agreed that the second half was much more successful (and the good work was continued at a return concert at Smallfish the following night) but the value of the manner in which it was achieved was much discussed. SOH was unhappy that I had acted so autonomously and “without caring for others” in starting so violently and without any warning. I had broken a form of ‘cooperative contract’ between improvisors. I agreed that I had, and that I had acted wilfully in so doing, but felt that there was a musical justification in creating a setting in which, whatever else would occur, it would not be the lame FIFO of the first half. I was delighted that SV had undercut me and shared the joke. On reflection however, SV was apologetic – to me for ruining my Big Gesture, to SOH for the crude quotation. In the pub afterwards, an electro-acoustic composer criticised the band for our “cultural indexicals”. I retorted that all social action was culturally indexical and that it was an “acousmatic conceit” to believe otherwise. The composer accused me of “aesthetic relativism” and bought another beer.

Unlikely Atoms and Enforced Comping: Stockholm, Limerick and Norwich

Whatever the outcome of bar-room polemics between academic musicians, all sides can agree that musical materials, the social interactional relations between performers, their technological provision, and the forms that improvised music can take are closely intertwined affairs. One might differ on the value of different configurations – both aesthetically and ethically. But practically accomplished configurations (of materials, interaction, technology and form, etc.) they are. Sometimes a certain configuration will be pursued wilfully, by design. Othertimes configurations are achieved without prior will or articulation. A configuration can take us all by surprise.

For about a year following the first Z3 concerts, it became my settled practice to combine physical manipulable devices with autonomous algorithmically generated material and points in between – very commonly organised around particular ways of using an onstage DJ mixer desk. This was the schema for solo, duo and other formats. However, four concerts over the

period of November 2001 to February 2002 varied the picture to a degree. While the distinctions between different kinds of interactivity were maintained and performance environments were designed to ensure the right ‘coverage’, the simple mapping to the three channels of a DJ mixer was relaxed. This was not so much for reasons of principle, more to do with the fact that the mixer was too large and heavy to usefully take in aeroplane luggage. At the cost of losing the cross-fader and the aggressive cut-filters, one could gain more channels in the lighter weight design of small studio mixers. Substituting a ten input studio mixer for the six input (three channel in the DJ way of counting ‘channels’) DJ mixer enabled me to experiment with two independent synthesisers, four contact mikes, laptop audio and minidisc material permanently on tap (rather than a source toggle switch away) at two concerts at Fylkingen in Stockholm.

At the first of these concerts, while working with Z3, I found myself playing the amplified table-on-wheels as recounted at the beginning of Chapter 1. The second concert offered some other surprise configurations. First, the organisers of the event wished to augment established performer groupings. I improvised with SOH and Ann Rosén as a trio. Later I played with SOH but in a live video interaction experiment with Fredrik Olofsson. Fredrik’s software reported on changes in the video image as MIDI – much like the software we experimented with at the Ipswich 12. SOH and I were to assign the MIDI data to some of the parameters in our sound models while performing other aspects of sound control manually. I hurriedly built a computer application to route, re-map and scale the MIDI data from the video analysis before it was output to my synthesisers. It soon became clear that MIDI had failed in and out of the computer – possibly (we later reasoned) due to the density of data from the video analysis application causing MIDI drivers to crash. SOH suffered the same failure. We had to accompany the video (made by Ann Rosén with playback transformations by Fredrik) with manual synthesis control – a knob turn at a time, or maybe two, one in each hand. While this constrained the kinds of moment-by-moment transformations we could make, the establishment and slow tweaking of textures worked well with the video.

Immediately segued from the video was an improvisation involving all performing parties to the event. SOH, Fredrik and I were joined by Ann, SV and Marianthi Papalexandri-Alexandri. I moved more or less exclusively to working with the contact mikes, the pieces of metal some of them were attached to, and the various means I had for stimulating the constructions (vibrating pens, a selection of fans, an egg whisk, bare hands, etc.). My sustained synthesiser sounds had become hard to control after the MIDI failures, and anyway I wanted to allow space for the other four sounding contributors. The performance is marked by a gradual reduction of density until at the end we are all playing very punctate sounds whether their origin be acoustic (Marianthi under the lid of the Fylkingen Steinway), amplified (bursts of rotating fan blade on metal), electronic (glitchy synthesis from Ann) or whatever. The emergence of these atoms and the various patternings they can take surprises us all. We work with them for several minutes before making the music sparser and sparser, then stopping.

Two weeks later SOH and I are performing as a duo in Limerick, Ireland. I have to travel even lighter than most trips abroad as I was visiting Sweden, then Italy, in consecutive days before arriving in Ireland. I also know that our performance will be in a lecture theatre which is being continuously used immediately before we are due to start. I decide to work only with my laptop and Nord Modular synthesiser. To save on bringing an onstage sub-mixer, I route

the laptop audio through the synthesiser and write a minimal patch which gives me amplitude control over the laptop sounds from a knob on the synthesiser. For this once, I also bring no special interaction devices. I interact with the synthesiser and mix the laptop audio entirely through knob turning on the synthesiser front panel. Even with this minimal set-up, I make a contrast in interactivity between the more direct control of the synthesis patches and the less direct, more algorithmically derived material emerging from yet another attempt at authoring a composition machine running on the laptop. As soon as we start, it is clear that I am substantially quieter than SOH. I cannot punch through intense dynamic peaks even with all my volume knobs fully clockwise. I have to serve primarily as SOH's accompanist. I have to ensure that his dynamic emphases are brought out and not negated. I have to select textural material which will set off his more gestural work. Though I am lower in the mix, this does not make the performance less dynamic. From time to time, SOH gives way and my sounds appear alone and quietly so. My quieter contribution shapes the performance by subtle means. I create four or five different 'environments' for SOH to work within, the last one being a 'slight return' of an earlier one, so suggesting an imminent closure.

A concert in February 2002 provides another example of 'enforced comping'. I am playing electric guitar. It is laid flat on a table, the strings are slackened and damped, various devices are used for forcing sound out of it. The guitar's audio goes first to a commercial pedal effects unit and then to my laptop where some homemade live processing software resides. This can be controlled by means of a computer gaming joystick I have connected to the laptop. The arrangement makes for effective two-handed operation – the right hand working the guitar, the left shaping its processing. The processed output is sent to the main mixer desk and to a second laptop running an application authored and controlled by Ed Kelly. Ed's software was initially developed to sample live and algorithmically play back percussion sounds in his combined percussion and electronics piece *Entanglement* (2001). Its live sampling capability works by detecting transients in input audio and automatically storing the impact which follows. Various algorithms are available to select sample groups for playback and to vary their ordering. The output can also be mixed with granularised and comb filtered versions. In our duo performance, my already processed guitar was the source for Ed's software. His bursts of sampled guitar impacts combining with my 'source material' in the overall mix. We called our performance *Strangled*.

As before I wanted to effect a variable instrumental identity for the guitar while creating a viable working environment for performance. As this time the guitar was the sound source and so clearly on view, I wanted to explore what I called 'historical guitar sounds' rather more than in the early work with Z3. These included a variety of rock music sounds: sustained feedback textures, pitch bends, and pastiche miniature solos with very fast picking. They were produced on the table-top guitar with varying degrees of comfort and success. Easiest to bring off in this configuration were sustained feedback textures. I had programmed the effects pedal to artificially generate a feedback effect and I could sustain sounds by holding a string down hard and causing it to rub against a fret in standard rock fashion. When further processed by my laptop, the result was a spectacular layering of an historical guitar sound with electronic substrates. In performance, this seemed to me to be an appropriate big texture to (begin to) end with. However, this large texture gave no new impacts to Ed's software. As Ed's sampling techniques worked entirely automatically, he was without new material throughout my work with this texture. He was reluctantly forced to comp. As soon as

I release the texture and play a few events intending to close the piece, Ed starts up again, now finding his sample buffers replenished with new material and hence released from the frustration of enforced comping. Ed and I make several attempts to finish as I play textures which are designed to effect closure and which (inadvertently) marginalise Ed's contribution, whereupon Ed replies by reasserting himself at the next opportunity, opening things up again.

My Prickly Head and the Starship Enterprise: Mestre

Across the lagoon from Venice, SOH and I played a highly successful concert in June 2002. While I travelled light, I had developed several applications for simultaneous usage on the laptop. I could mix in two minidisc players and had a great variety of material on disk, including recordings of several studio improvisations. I had brought four contact mikes which I mixed through a small effects unit, along with a pocket Theremin which I remembered to switch on this time. Overall, I had given some attention to maximising the 'bang per kilo' ratio of the equipment I was travelling with. We had also confirmed that the house 24 channel mixing desk could be repositioned between SOH and me. I stood stage left and mixed my sources into channels 1 to 6. SOH stood stage right and mixed his sources into channels 21 to 24. As the audience looked from left to right, they would encounter first SOH and his various items of equipment, then the large, long mixer desk, then me and my retinue. "It looked like you had just stepped onto the bridge of the Enterprise and were trying to figure out how it worked", remarked an audience member afterwards. We played comfortably for an hour or so and were given an extremely enthusiastic reception. We nearly had to perform an encore.

Afterwards I discussed the performance with a number of audience members – several of whom reported a common anxiety at the beginning of the performance. I started by taking a contact mike in the palm of each hand, bending my (shaved but prickly) head forwards, and gently rubbing the mikes against the stubble. The rustling sound proved eminently playable and characteristically different from any of the other collisions and scrapings of mike against material that I had at my disposal. "We were sure something had gone seriously wrong. We were worried that some of your equipment was broken. Why else would you take your head into your hands like that? It took us a while to realise you had started playing."

Issues

Let me bring out some analytic issues from the foregoing incidents. As will be made plain in the next chapter, these issues form the basis of design concepts which are worked through and exemplified in a number of key software development projects. I wish to pull out five particular issues for discussion, which I list here by way of overview.

- The importance of understanding the *contingent practical configurations* which interrelate technology, musical materials and form, performance practice, the specifics of setting and occasion, and different understandings of improvisation.
- *Variable sociality*: noting the different social interactional relations that are worked

through in performance.

- *Variable engagement and interactivity*: noting the different and varying relations that performers have with respect to their instruments and technologies.
- *Musical materials*: noting the range of musical material which have been experimented with and their different interactional features.
- Along the way, I develop a sketch of a potential *aesthetics for improvised electro-acoustic music* which seems idiomatic for the analytic approach of this chapter and the design orientation of the next.

Contingent Practical Configurations

I have tried to document a number of significant contingencies which need to be negotiated in bringing off a performance of improvised electro-acoustic music. We have seen examples of performances reckoning with the specifics of the setting: the reverberation at Siena, the restricted access to the performance space at Ipswich, Limerick and Smallfish, the cushioned floor at Fylkingen. We have seen performances adapting (not always successfully) to technical contingencies: MIDI and monitoring failures at Fylkingen sustained guitar textures giving a live sampler nothing to go on at Norwich. We have seen performances having to fit into concert programmes and other forms of scheduling often beyond our control: the lecture-recital format at Siena and Huddersfield, the segued concert at Fylkingen, the two-part performance at City. On site preparation time has varied from several hours (UEA) to next to nothing (Limerick and Smallfish). My ability to transport equipment has varied from using a van through to whatever I was willing to struggle with up the hills of a mediaeval city. The important point is that all these matters are wrapped up with the kind of music which was performed. One could play the reverberation at Siena and generate rubbing sounds as a table moved across the cushioned floor at Fylkingen. MIDI failures made performers resort to knob control of synthesisers with the characteristic gestural content music controlled in this way commonly has. Monitoring failures led to overplaying. A two-part concert programme induced timidity, frustration and controversial solutions. Travelling light and no set-up time enforced comping. At the Hybrids music festival in Norwich in July 2001, an open-air performance by Z3 was deemed too noisy by nearby residents. As good citizens, we performed a restful piece to close our set. And so forth. Of course, in each of those cases, things could have turned out differently: there is no iron law which relates my ability to carry weight to the musical roles I can assume. However, if things had turned out differently, it would be through *other* ways of negotiating the manifold contingencies of place, technology, programming, and preparation amongst other matters. This is the point I wish to establish: *the music has arisen in relation to these contingencies in such a way that, from an ethnographic point of view, it should not be analytically separated from them.* In contemporary musicology, there is much debate over the value of making an analytic distinction between the musical and the extra-musical. Kramer (1995), for example, draws on poststructuralist and postmodern theorisations to cast this distinction in a critical perspective. By contrast, my remarks are empirically motivated: to get the story told with recognisable adequacy and completeness I continually criss-cross affairs which would normally be segregated.

The situation I have described – one of manifold contingencies negotiated in shaping a musical practice – is not unique to improvised electro-acoustic music, though perhaps this kind of music makes the issues most perspicuous. I have described practices which are radically heterogeneous with respect to musical materials, technologies, settings and aesthetic expectations. If we are to understand this music as a socially organised form of music making, we have to study and reflect upon the practical methods members use for giving order to this heterogeneous mix. Many forms of music making might be thought to have a single or a small handful of resources for giving order, for practically configuring the music as a social accomplishment. This might be a melody, a raga, patterns for trading fours, a score or whatever – a thing which is held in common and to which parties to the performance are accountable (see Chapter 1). Over the course of the performance history I have recounted above, we can see that way of managing musical resources and making ourselves musically accountable gradually losing its grip. Once, we were tempted to have pieces of paper to guide the enactment of waves of intensity. On another occasion, I sketched out a three-part structure with different things happening in each part. To emphasise its status as an accountable means for performance organisation, it was published as a programme note – in principle, our success or failure in its realisation was on public display. As a third example, one of us edited a soundfile to precipitate the organisation of performance from within, just in case things didn't gel in a new trio. Such structuring methods have not been eliminated. Rather they have lost their privileged status. Pre-recorded material and the output from software composition machines enter into the mix alongside whatever else I and the others have brought along. Such resources may turn out to precipitate everything else to fall in line, or they may get ignored. Offerings and enactments of structure are beset with contingency – just like everything else.

The image of improvised electro-acoustic music that I want to experiment with is one where these contingencies (of place, structure, technology and the rest) are not seen as problematic obstructions to an idealised performance but are topicalised in performance itself. Improvised electro-acoustic music, on this account, *precisely is* that form of music where those affairs are worked through publicly and in real-time. The contingency of technology-rich music making environments *is* the performance thematic. The whole point is to exhibit the everyday embodied means by which flesh and blood performers engage with their machines in the production of music. The point of it all does not lie elsewhere or in addition to that. It is in our abilities to work with and display a manifold of human-machine relationships that our accountability of performance should reside. The reader should beware at this juncture. I am knowingly shading an analytic account of some features of my improvised electro-acoustic music making into a sketch of an aesthetic for that music. Analysis and aesthetics are two different activities and one does not entail the other. I do nevertheless find an affinity between the ethnographic orientation I have taken to analysis and the aesthetic situation of certain kinds of improvised electro-acoustic music. While not an entailment, the one does seem idiomatic for the other – a relationship I will continue to add detail to over the next few sections.

Variable Sociality

In addressing the contingencies of improvised electro-acoustic music making, performers vary in their social interactional relations with one another (cf. Heath et al. 2002) who make an analogous point regarding the varied forms of participation visitors to an exhibition can have in appreciating works of visual art and craft). Imbalances of amplitude and ability to control dynamics might lead to one performer adopting an accompanist's role for another as at Limerick. Performers might ensure that they make atomic contributions to maximise space for others (Fylkingen) or one might assert a definitive character to a contribution which makes it problematic for others to respond (City and UEA). Improvisors can cooperate in the enactment of a shared structure (Siena and UEA) or be prepared to attempt engineering a structure without the explicit awareness of others (Smallfish). Roles and responsibilities can be pre-assigned and perhaps technically mandated – for example, one performer can be a source for another's live sampling/processing (UEA). Alternatively, all performers might have a range of resources to permit relationships to be reconfigured ad hoc (the typical Z3 picture). Not surprisingly, members can be heard arguing over the requisite care that improvisors should show for each other (City and UEA again).

In the performance history I have recounted, all of these alternatives have been variably experimented with, often interchangeably during the course of a single performance. I do not wish to assert the viability of any one over another or rule any out as aesthetically or ethically illegitimate. Indeed, any such ruling would itself in turn have to negotiate contingency in its enactment. One might set out with a particular local sociality of performance in mind but find oneself gravitating to another because cables aren't long enough, the monitoring is lopsided, somebody gets frustrated, bugs show up in software, the audience begins to leave, or whatever. Particular configurations of contribution have different yields, different profiles of utility and difficulty, different characteristic productions associated with them. At Fylkingen, we found ourselves making an atomic improvisation, searching and reflecting as if we were good followers of John Stevens (cf. Chapter 1). Our patterns of interactivity with each other were productive of a characteristic musical form. Other forms would not be accessible that way: a dense layering which causes local residents to complain for example. Of course, we can debate the value of these different forms. My point is an analytic one: the forms and the local sociality of their production have an intrinsic tie.

But let me make the same shading of an analytic point into an aesthetic possibility as I did before. Perhaps this palpable variation in the sociality of musical production is an important feature of improvised electro-acoustic music. Publicly displaying the different ways in which performers can position themselves with respect to each other and the different ways in which technologies can be deployed to enforce, negate, mesh with, disrupt, or otherwise relate to the local socialities of performance could again become the whole point of doing it.

Variable Engagement and Interactivity

Just as performers can variably relate to each other, they can variably engage with the technologies and instruments before them (again cf. Heath et al. 2002). My account of the

Ipswich 12 emphasised how, in dealing with the practical contingencies of staging a twelve hour event, we worked with technologies with a degree of autonomy – that is, music could be produced without moment-by-moment human incitement. This relationship with mechanised music production has been carried through in subsequent work: the composition machines I have used with Z3 for example. The musician might set parameters or select source materials. The machine can then do its stuff. The musician might mix the machine contribution alongside other materials and then later re-set parameters or select new materials. And so forth. Perhaps one can characterise this pattern of engagement as one of *initiation, delegation, supervision and intervention*. The performer initiates a mechanised contribution, delegating music making to some technical arrangement. Its productions are supervised and, from time to time, adjusted and intervened upon.

In contrast are musical resources which require human incitement to action, which are mute without it. Traditional instruments are characteristically of this sort, needing some transfer of energy from the performing body to a sounding object. Cook (2002) argues that such sound-producing interactions are actually rather small in number. He hints at a taxonomy with just three basic classes: blowing (which includes vocalisations), striking (which includes plucking) and rubbing (which includes bowing and scraping). The great variety of the world's acoustic instruments derives from how these basic gestures work with specific physical mechanisms of sound production, as well as how other gestures might modulate a sound once initiated. Perhaps one can characterise this pattern of engagement as one of *physical excitement/incitement and manipulation*.

Naturally, this picture of forms of engagement can be complexified. We can think of different activity envelopes for traditional instrumental interaction and in this way distinguish percussive and other gestures. We can imagine interaction with electronic sound on the model of traditional instrumental interaction, as is the case in most commercial synthesisers, or we can think of hybrids and combinations of various sorts. One particular combination characterises much of my synthesis work in the concerts described in this chapter. An overall envelope is set either by an electronic instrument modelled on a traditional acoustic counterpart (e.g. the Yamaha wind controller) or by a contact device or hacked game controller (e.g. a touchpad establishing a touch-release envelope). Between onset and release, data are extracted which parameterise musical algorithms. In the case of the wind controller, these data concern bite and wind pressure, on the touchpad 2D coordinates. I typically work with these devices so that a sustain mode is possible where releases are ignored. I might also introduce controls which variably weight the contribution of data values extracted at onset. This can enable interactivity to move between direct (cf. many traditional instrumental forms) and indirect (cf. composition machines and algorithmically mediated forms) modes. Other than identifying some basic points of reference and some hybrid forms, I do not wish to push a particular taxonomy here. My point is that there are many different forms of engagement a performer can have with a mechanised/acoustic arena for musical action. It becomes tempting again to suggest an aesthetic for improvised electro-acoustic music in terms of the public display of this variation and how one can negotiate transitions within it.

The incidents and history I have recounted help us discuss three further practical points concerning the different forms of engagement and interaction that are in play in performance. First, different forms of engagement have different *phenomenologies* associated with them.

One can have varying senses of one's capability in bringing about sonic effects. The body, and different parts of it, are variably implicated in sonic production. Listening can take different forms depending on whether one is listening as one is bodily engaged or listening to an independent machine production. Second, different forms of engagement gravitate towards different *time scales*. The productions of a composition machine may be available under the cross-fader enabling long-ish episodic structures or recapitulations as the fader is flipped from one side to the other. Such algorithmic material or the playback of recordings may 'buy time' for the set-up and initiation of other materials. And so forth.

With such varying forms of engagement and senses of interactivity in play, it is certainly possible to lose *intelligibility* (and this is our third area of practical concern). The *Channelling* performance is probably the clearest example to hand of the dislocations which can occur. Indeed, if one is working with multiple forms of engagement simultaneously, this can introduce a further layer of complexity in the intelligibility of performance gestures for the performer, co-performers and audience. Several commentators on live electronic music are most concerned about the loss of legibility that gestures can have in technologically mediated performance environments (e.g. Emmerson 2000b, see also Smalley's 1986, p83, remarks on 'remote', 'dislocated' and 'unviable' 'surrogacy'). But there is no necessity here. My account of how we enacted the planned waves of intensity at Siena should reveal some close coordinations between players of bodily gesture with respect to touchpads, keyboards and knobs. I ensured that critical knob adjustments were made visible to SOH by carrying through the local turning at the front panel into a perspicuous whole body movement. In the context of the unfolding music and how it enacted the score, this gestural sequence was legible to SOH as accomplishing the transition into the final section. I assume that, just as my activity was visible to SOH, it would have been to the audience. It would accompany a notable transition in intensity and could be interpreted as bound up with its production. The audience would not have the same resources as SOH, however, for drawing the precise implication that he did (here we are in the score) but my movements would not be meaningless thrashings.

The ill-considered multiplication of musical resources in *Channelling* (and the mistakes I made as I nervously performed) did not support such patterns of practical implication on the part of SOH or audience members. But, as argued above, more resourceful environments are musically sustainable provided that they are coherently organised. Materials and interactivity were patterned in the Z3 concerts across a whole performance set-up, unified around the distribution of channels in a DJ mixer. The mixer enabled recognisable gestures to be performed at the cross-fader. The set-up also extended the left-right sense of organisation of the mixer into a within-reach-at-the-tabletop local arena for action – a *performance ecology* if you will. Guitar to the left and physically manipulable. Computer to the right and running composition machines. Synthesiser centrally placed offering knob control over noodling patches amongst other things. The point here is that by moving from one side of the table to the other I can do different things and be seen to be doing different things – different in gesture type, device type and sonic consequence. Not only does this 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. I do not wish to overstate my achievements here. My concern, rather, is to suggest that there is no necessary unintelligibility regarding performance environments with multiple musical resources each with a different pattern of interactivity and engagement. It all depends upon the organisation of those environments.

Design principles for such performance ecologies and for the technologies which are implicated in them will occupy us repeatedly in the rest of the current work.

Musical Materials

I have emphasised the construction of heterogeneous performance environments with different devices and forms of gestural engagement coexisting in a structured coherent manner. In the performance history I have told in this chapter, I have hinted at the range of different materials which have been pressed into musical service. Let us give some fuller listings. Recordings which are played back with various transformations include: acoustic improvisations, soundscapes, physical machines (especially steam engines), sounds of mechanical computer operation, by-products of SSB (single side band) short wave broadcasts and other radio sounds, vocalisations, prepared texts, domestic sounds, toys, amongst many other sources. Synthesis techniques have included: waveguide-style physical models, 'classical' analogue synthesis sounds, granularisation, vocoding, time-stretching and pitch-shifting, chaotic self-modulating FM oscillators, again amongst many others. Physical manipulables have included: acoustic and electric guitars with various modifications (e.g. 'The Hacked Axe'), Mechano models, metal plates, a homemade lyre, objects placed in a Pyrex bowl ('The Mixing Bowl' – sic) along with various microphones and transducers, vibrators and electric motors, fans, the tone-arm stripped out of a record player with the needle and cartridge stroked with finger tips or rubbed against a CD ('The Tone-Arm Bandit' – sic), toys, a guitar homemade out of driftwood and stones from the beach giving tension to the strings ('The Strandline'), an ashtray, my prickly head, and so forth.

To construct workable and intelligible performance environments, I have made various distinctions between these musical materials in terms of their real-world sources, the media by which they are conveyed, the manipulability of those media, the kinds of gestures and devices which are used to realise those manipulations. From time to time, all of those features are seen to be bound up with identifiable forms of social organisation between co-performers, and those forms of interaction have musical-formal aspects to boot. I have tried to reveal these interconnections through ethnographic description of the performance situation.

In case the reader had not realised it already, I must now emphasise how radically different this approach seems to be from the methodological strictures of acousmatic composition and the allied practices for reasoning about sound associated with Pierre Schaeffer (1966) and his followers (e.g. Chion 1991). As is well known, Schaeffer urged a compositional practice in which sounds were to be reasoned about and practically assembled and juxtaposed without reference to the real-world objects which cause those sounds or to which the sounds 'refer' in some sense. Of course, it is debatable whether such 'commandments' (as Chion 1991 has it) are intellectually coherent – as is the extent to which Schaeffer himself followed through this programme in strictness in his own work (see the various positions taken on Schaeffer's ideas in Emmerson 2000a). I read Schaeffer polemically – that is, as rhetorically positing an extreme argument to enable new practices to be formulated and systematised.

While careful Schaeffer-exegesis is beyond the scope of this current work, the practical means by which sound is actually produced is very much my topic, as it is this and how it is socially

accomplished which I take as formative of music under conditions of improvisation. This, though, is a different topic from those which writers commonly raise in criticism of Schaeffer. For example, Windsor (2000) uses the psychological theory of perception associated with J. J. Gibson to insist that “the sources of sounds may be harder to ignore than one might hope” (p16) while not ruling out the kind of physical-phenomenological description that Schaeffer preferred. For Gibson, active perception is a matter of ‘picking up’ on ‘regularities’ which are causally tied to objects. As biological organisms, we come to sense objects directly in our experience of them rather than, as cognitivist theories of perception would have it, through the interpretation of mental representations. For his part, Emmerson (2000b) emphasises the mediation of recording and reproduction technologies and how we are becoming more sophisticated in hearing their traces. This again is counterposed to acousmatic ideals of transparent reproduction technology which would enable the free play of sounds as sounds. Neither line of discussion is clearly engaging with the real-time socio-practical conditions of music production in quite the way I have tried to do. For me, all these matters – the nature of perception, the transparency of media and reproduction technologies, the causality and referentiality of sounds – are to be understood as social interactional and practical affairs.

When *The Girl from Ipanema* rang out after a dark industrial guitar kerrang, to be sure one was confronted with something with an immediate recognisability and a juxtaposition of musical forms and cultural allusions. One was also presented with a musical and social interactional problem: how (on earth) to proceed? The musical sequelae were concerned with addressing that and not so directly with further juxtaposition of cultural allusions. Sustained historical guitar sounds to be sure had a culturally informed recognisability and a visually as well as sonically available source: the electric guitar. But they also had impacts on the forms of interaction that could take place between Ed Kelly and myself as the music went on. At Limerick, while I was getting used to accompanying SOH, I played some recordings which featured footsteps on gravel – lots of small percussive events as stone hits stone ‘underneath’ a larger one as foot hits gravel. The composite of percussive detailing was mirrored by some of SOH’s granular synthesis work. With Z3, SV’s percussion engendered episodic transformations as a bang-crash was heard to terminate what had gone before. In response, we looked for new materials. At another moment, SV established a suspended texture while SOH and I exchanged bursts of activity beneath. In all these cases, the character of the sound deployed was configuring the interactional opportunities available. Whether we choose to complement, transform, contrast or ignore what has gone before is heard in terms of the locally produced affordances (to follow Windsor for a moment in his use of Gibsonian terminology) of the music. These affordances are multivalent and interactionally produced and sustained (on the notion of an ‘interactional affordance’, see Bowers and Martin 1999). An excerpt from *The Girl from Ipanema* can be heard as lounge music or soft jazz, as a particular melodic or harmonic form, as a specifically shaped ‘spectro-morphology’, and so on. Footsteps on gravel can be heard as a Foley-style rendition of the activity of walking, as a rhythm, as a granular texture, and so on. In improvised performance, it is indeterminate in advance which of these features (if any) will be taken up by co-performers. If one is, then a locally produced thread of significance comes into existence which can be further complemented, transformed, contrasted or ignored. And so on. An electro-acoustic improvisation can move between quite different principles for the construction of these threads. Similarities and contrasts between sounds may be produced on spectro-

morphological grounds or through musical genre allusion and juxtaposition. Whatever. The point is that we need to understand the interplay of sound quality and interaction to grasp what is going on in the real-time accomplishment of electro-acoustic improvisation.

From this point of view, we can recast many of the theoretical and taxonomic contributions to the acousmatic musical tradition in a novel way. We can see, for example, Smalley's (1986) spectro-morphological categories as indexing not (or not just) intrinsic properties of sonic objects but as picking out interactionally relevant features for the coordination of improvised conduct. A contribution which Smalley might deem an instance of a 'graduated continuant archetype', we could see as offering sustained opportunities for co-performers to join in the production of a multi-layered texture. A 'canopied pitch-space frame' may come into existence precisely through one performer offering a suspended texture under which the others work. Smalley's various 'motion styles' can equally be seen to be descriptions of forms of interactional coordination ('synchronous/asynchronous', 'periodic/aperiodic').

On related lines, we could begin to unpack the interactional dimensions in Emmerson's (1986) distinction between aural and mimetic discourse. Our recasting of Smalley precisely concerns how an aural discourse, assembled on a basis of spectro-morphological relations, could be interactionally produced real-time. By contrast, the sound of a 'bang on a can' (cf. Emmerson 2000b, p198) may establish a mimetic discourse or invoke the 'object/substance' and 'energy indicative fields', not to mention the 'behaviour' one too (cf. Smalley's 1992 rather analytically blunt distinctions). It might also be a real bang on a real can performed by a flesh and blood human performer. As such it will have practical and interactional features, and not just sonic ones, which will make it different from, for example, the algorithmically composed texture under the cross-fader on Channel 3. Working with it will afford different coordinative possibilities than flipping the fader across to Channel 3. And again these coordinative possibilities are matters to do with the activities of folk embodied here-and-now rather than their (represented or alluded) sociality in a 'behavioural indicative field'.

Emmerson (1986) goes on to discuss two different ways in which an overall musical structure or 'syntax' can emerge. A syntax can be abstract and impose an organisation on the materials – for example, through the use of mathematical formulae or serialist techniques. Alternatively, a syntax can emerge from within the musical materials themselves. Emmerson calls such forms 'abstracted' (I would have preferred 'immanent'). Improvised forms are naturally immanent, ad hoc-ed moment-by-moment on the basis of what has gone before and projecting opportunities for what might come following. In the language I hinted at above, multiple threads of significance may link up several of the elements in play. There may still be singularities and other 'unattached' offerings. The threads may be thin or may be densely interwoven (steady with the metaphor now!). We may have a sense of 'a piece' or a collection of 'moments' or some point in between. These are some of the immanent forms, of abstracted syntax, one can hear generated by electro-acoustic improvisors. It is not so easy to perform serialist permutations, calculate the Fibonacci sequence or find arbitrary prime numbers in the throws of performance. But one can delegate that activity to a machine for real-time calculation and operations of this sort are well represented in literatures on computer music (see Rowe 2001 for example) as well as being anticipated in such classic texts as Xenakis (1971/1992). The real-time situation of improvised electro-acoustic music interestingly illuminates and refines Emmerson's distinctions between different forms of structuring. One

can, for instance, imagine a structural thread which is abstract in Emerson's sense, instantiating an arcane mathematical principle, yet still interactively shaped and responded to.

Machine Music Aesthetics and Musicological Methods

The stance of the current work is very different from that of acousmatic musical researchers, even if many of their traditional concerns can be interestingly reoriented. Famously, Schaeffer drew a loose analogy between the liberation of sound from its source and Pythagoras' practice of lecturing from behind a screen (the *acousma*) so that the logic of his words could be assessed by his pupils independently from his personal authority as speaker. The acousmatic Pythagoras offers a picture of a highly rationalised accountability and the hope of a formal language shorn of any personalised indexicality. While this might mesh with many ideologies of science, and Schaeffer was known for his scientific aspirations for acousmatic exploration, the current work offers a different view both methodologically and, I believe, aesthetically.

I have studied improvised electro-acoustic music ethnographically. I have done so through participant-observational study of the everyday practical activities of myself and colleagues as music makers. The emphasis has been on description, where possible detailed description, to bring out a sense of the manifold contingencies which are encountered as we ply our trade. My aim is that 'competent members' (that is, other improvisors) could recognise their activities in my descriptions. This sense of recognisability is my criterion for intellectual or scientific adequacy. I do not seek any formal language in which I might express universals which have a validity or logic independent of specific communities of utterance and practice. Indeed, I accept the indexical ties which exist linking my accounts to specific musical situations on the one hand and to the communities that produce and understand them on the other. My hope is that my work is adequate to the explication of such ties. It is not concerned with their suppression or overcoming. There is no methodological *acousma* here, no occlusion of (distrusted) vision or personal participation to engender a purer truth. On the contrary, the hope is that by making my agency plain in what has occurred, the reader is better able to assess the work's descriptive adequacy and what follows from it. Readers – like electro-acoustic concertgoers if not geometry students – are after all a sceptical bunch able to make up their own minds. For their part, members are not always concerned to explicate their own practices – or at least not concerted, they might occasionally when the need arises. The dense explication of practice is the duty of the ethnographer. But there is not in this any sense of the cognitive superiority of the current account over any of the occasioned productions of members. These are different kinds of account, with different kinds of occasioning and different purposes. My aim is to give an account of what I have seen of electro-acoustic improvisation that is descriptively adequate in the sense just given and informative of design – a promise I will try and deliver on in the next chapter.

There is a parallel in my treatment of questions of (ethno-)musicological method and electro-acoustic musical analysis. Neither needs an *acousma* or any other special technique to secure a practical viability. I do not feel I need to distance myself from my own participation in the events I have described either to produce a sense of objectivity or to ironise my text's 'reality effects' (contra many of the anxieties in recent sociology, ethnography and musicology, for a

selection see: Woolgar 1988, Hammersley 1997, Kramer 1995). Equally, I have argued that an understanding of ‘sound objects’ which embeds their production in incarnate and technologically mediated musical practices is called for. It is in practical configurations of human bodies, machines and other instruments that sounds are engendered. If one is to understand the organisation of improvised electro-acoustic music, one needs to understand how participants coordinate their activities as they work in such settings. These are settings with variable forms of engagement and interactivity as heterogeneous materials are publicly worked with in performance.

I have already flirted with making a qualified aesthetic leap here. The open exhibition of the many and varied forms of interaction and engagement that can exist with such machines and materials *is* the aesthetic point of improvised electro-acoustic music. How we struggle with those machines, how we cooperatively work with each other (when we do) to make them work, how our practical activities are productive of forms of music, how we succeed and how we fail and the complex senses those evaluations can have, how we can lose ourselves in a machine world yet also come to terms with it and make it manageable, and how we can do all those things right here, right now – these are the preoccupations which make up the aesthetic identity of improvised electro-acoustic music. These may also be some of the critical preoccupations of many audience members. Recall the comparison made in Mestre between our performance environment and complex machinery which we were struggling to control. Recall also how well primed several audience members were to interpret my head rubbing as anxiety over technical failure. The exhibition of human struggles with fragile complex machinery makes familiar territory for audiences. Let us take those matters, not so much as design challenges to be overcome, but as explicit features for aesthetic enquiry.

These are also matters which give the music a specificity. While other musics encounter such issues from time to time, improvised electro-acoustic music has these features inscribed into it with some intimacy. Again, there is an affinity of method and aesthetics here. Many artists and theorists would seek a definition of aesthetic aims which would translate certain practice-specifics out of the picture. For example, we commonly hear of musicians seeking aesthetic goals which instrumentalise their technologies (see Wishart’s remarks at the beginning of this chapter) or make them transparent (e.g. Bahn and Trueman 2001). The artefacts they work with are mere means to aesthetic aims. On the other hand, there is a tradition of aesthetic critical thinking which wishes to understand technologies as internal to artistic practice. Walter Benjamin’s (1927) essay on the work of art in the era of mechanical reproduction is a locus classicus in this regard (for a recent critical study of Benjamin, see Leslie 2000). However, such arguments are often put abstractly with technological interactivity being rendered according to a preferred theory of sociality or subjectivity (Cubitt 1998 is a recent case in point, but there are many). Rarely are examples of practically working with technologies for aesthetic ends presented with analytic empirical detail. I have tried to make a start at doing this in the case of improvised electro-acoustic music (cf. Bowers 2000 for a similar treatment in another creative domain). The topics I have suggested *in their specificity* to improvised electro-acoustic music could be rearticulated as that music’s *specific* aesthetic preoccupations.

In Chapter 1, we saw Ingrid Monson offering a case that certain interactional features of jazz made it a specifically Africa-American cultural practice. While I was cautious about the

details of this argument analytically, if a music is to be linked to specifics of cultural practice, aesthetics and politics, then Monson has informed those issues the right way – through an analysis of the practically produced texture of the music itself. Improvised electro-acoustic music, on the aesthetic view I have been experimenting with, is not tied to the same order of cultural politics and identity as jazz might be. I am not seeking a positive definition of improvised electro-acoustic music as a politicised cultural production along ethnic (or gender) lines. Rather, I am presenting electro-acoustic music as an arena where our varied relations to machines can be explored as indigenous to the music. Improvised electro-acoustic music in performance settings allows us to publicly and accountably explore whatever collective human capability we have to design those machines and make them work. That seems like a worthwhile thing to do.

Chapter 3

Machines

Designing Musical Interaction

So far my writing has engaged with various conceptualisations of improvisation and presented an extensive documentation of my own experience as an improviser of electro-acoustic music. My major concern, though, is not to leave matters there but rather to follow whatever insights have been gained through into the practice of design and, naturally, through design into the music itself. That is, I wish to inform the design of the technologies I work with by analyses and arguments of the sort encountered in the previous two chapters. Exactly how this should take place is not obvious. There is a kind of practical indeterminacy in affairs of design, reminiscent of the indeterminacy of theory by data in the philosophy of science – the so-called Quine-Duhem principle. Just as any finite set of empirical observations is consistent with an indefinitely large number of theories which could account for them, the ethnographic work I have presented could motivate or inform design in a number of ways. Certainly, there is no single artefact which just must be built given the arguments so far. In the last chapter, I noted the slippage which occurs between analytic and aesthetic matters. I have yielded to the temptation to make aesthetic points on the basis of my empirical reflection – with both eyes open, however. A similar drift in rationality is required here, as we shade from empirical observation and aesthetics into design.

In the terms of the research fields commonly known as Human Computer Interaction (HCI) and Computer Supported Cooperative Work (CSCW), I am practicing ‘ethnographically informed design’ – albeit in a domain rarely studied in those fields (improvised electro-

acoustic music). The different ways in which ethnographic research could inform technical design have been variously reviewed and schematised (e.g., Hughes et al. 1994, Pycock and Bowers 1996) though these authors largely have workplace contexts in mind. At the risk of over simplification, let me briefly offer three ways in which one could pass from the characterisations of the ‘work’ of musical production into design. These are general orientations to the question of how to motivate design, not specific to ethnographic or any other kind of ‘informing-work’. They are a long way away from specific design commitments and even further from the kinds of things software engineers call ‘requirements’.

- *Meshing*. One might formulate design around a directive to create technologies which, in some sense, mesh with important features of a given practical activity. This orientation, conversely put, might have it that we should not design artefacts which disrupt the essence of the practical activity they are supposed to support or mediate. Principles of this sort leave a great deal unspecified – what sense are we to give a metaphorical term like ‘mesh’ or a theoretical one like ‘mediate’, what would count as ‘disruption’, ‘supporting’ and how can we identify the ‘important’ features of a practice which are at its ‘essence’ – but I hope I have done enough to capture the design orientation and moral stance of much of what passes as, for example, ‘user-centred system design’ and ‘participatory design’ (for a review of these orientations in HCI, see Preece et al. 2002).
- *Reifying*. An alternative stance is one which would take as the aims of technical design the reification or translation into formal machine terms of a description of a human activity or competence – perhaps with the aim of automation or simulation. Again, I hope I have done enough for the reader to recognise a familiar design orientation. Depending on one’s area of concern, this stance could be imputed to Taylorist-Fordist conceptions of industrial production, traditional Artificial Intelligence research, or work on automating ‘office procedures’ (cf. Suchman 1987).
- *Inciting*. Finally, one can engage in the design of an artefact so as to intervene in an existing practical activity and incite change in it, or at least reflection or pleasure on the part of participants. Much traditional artistic and design work is done on this footing. Bold industrial design and, for that matter, high modernist agendas in architecture commonly have this element. The concern is not so much to mesh with existing practice or to reify some feature of social life in a mechanism of some sort, but to create provocative artefacts. Gaver’s (e.g. Gaver and Martin 2000) design work would provide an example in the HCI field.

One might consider for a moment how, in generic terms, these orientations might relate to the account of improvised electro-acoustic music making from the last chapter. It could be argued that some of the performance difficulties I documented should be taken as specifying challenges for designing musical artefacts which better *mesh* with the concerns of improvisation and public performance. There is a small literature in computer music on the use of orthodox HCI design principles for producing more usable software and control devices (for a general review which also briefly discusses improvisation, see Roads 1996). This can sometimes be allied with calls for ‘new instruments for musical expression’ to use the title of a recently inaugurated series of conferences/workshops – the argument commonly being that new musics need new (useful and usable) tools. Alternatively, one might take the

nascent account of variable sociality and interactivity that I have begun to offer as a candidate for *reification* in software. One might feel tempted to formalise an account of social interaction in improvisatory settings and build simulations, perhaps ones which are themselves interactive. To give one example amongst several similar, Thom (2001) describes a system which can emulate the jazz idiom of ‘trading fours’ responding with musically plausible contributions in the light of the user’s input. My last two chapters have not been conducted with the aims of formalism in mind – and like many improvisors, I am concerned to engender a music where some obvious traditional formats are resisted – but a zealous formalist could still have a go. Finally, one could more or less disregard the descriptive accounts I have given and develop artefacts designed to *incite*, provoke, delight or whatever without regard for the detail of existing practices: here’s a thing, make of it whatever you will. While it occasionally nods its head in the direction of my other two design orientations, I find much of the work on musical controllers at the MIT Media Lab (e.g. Overholt 2001) positioned in this way. A design idea is postulated and a demonstration given, often making use of innovative materials, but without any extensive study of musical practice as background and with little empirically grounded evaluation of prototypes to follow.

Apparently, an ethnographical endeavour like mine could feed any or all of the design orientations I have discussed depending on whether one wants to mesh with, reify or provocatively ignore the accounts of music making I have offered. All of those paths have a *prima facie* rationality. However, they equally each have *prima facie* blindnesses. One can ignore the texture of existing practice in the hope of inciting novelty – but at the risk of being ignored in turn as irrelevant. One can embody practical details in a simulation – but at the risk of accusations of anti-humanism or of making foundational errors in understanding human conduct. One can provide technological mediations of existing practices – at the risk of accusations of conservatism. As our design orientations seem equally rational and blind (to flirt with a Heideggerian formulation for a moment), are we faced with an *aporia* of design motivation?

Variable Interactivity, Materiality and Sociality as Aesthetic and Design Concerns

In general, we might be. That is, as long as these issues are articulated at the level of generalities, we might be surrounded by doubt as to how to proceed. If our questions remain at the level of *how are new musical instruments (or software or ‘performance ecologies’ even) to be designed?* we will find it hard to make progress. One needs to refer to specifics of practice and purpose to understand how design should go. This is why I have gone to the trouble of developing an aesthetic for improvised electro-acoustic music making which is idiomatic for the kinds of performances I have documented. Naturally, this doesn’t tell one in detail what should be done but it configures the ‘design space’ and enables certain preferences to be articulated where, without, one might face a crisis of motivation and indecision in the face of equally appealing yet faulty alternatives.

My task now is to work out some more detailed design ideas which are true to my concerns for machine music. I have suggested an aesthetic which highlights the public display of the

variable interactivity, materiality and sociality which are at play as we collectively engage with musical machines. The purpose of design, then, is to create artefacts which make it possible for performers to engage with that aesthetic in a publicly accountable fashion. Seen in this way, there is not an essential motivation to, for example, build new musical instruments to enhance virtuosic expression or devices which are concerned to promote performer control of more and more musical features. One may want to exhibit musical machines that are out of control with performers struggling to intervene. One may resist automated solutions or indulge in them. And so forth. The point is that such decisions are made against a background of exhibiting variable human-machine relations.

In most of my performance work, I have adopted the strategy of *having a varied set of musical resources* before me which I have structured as an arena for activity, a *performance ecology*. Chapter 2 has explicated some of my practical rationale for this. The musical resources cross boundaries of technical idiom (acoustic, electronic, mechanical, computational), yet are used in conjunction and juxtaposition with each other. That a single performer works with these varied resources in each performance helps dramatise that it is those varied forms of machine-interactivity which are on show. I have tended to prefer this approach rather than one in which a performer works with just a single interaction principle. Winkler (1998) has an agenda for his compositional and multi-media work where each piece (or part of a piece) explores a fixed set of interactive relationships which endure throughout. Pieces where a traditional acoustic instrument interacts with a machine-generated part are especially prominent in his work, as are inter-media productions. This bias is shared in the work documented by Rowe (2001). Whether the acoustic sound is itself processed or is analysed in real-time for parameter values or is a simple source for triggers, this approach can make interaction into a puzzle for the audience to solve: do you see how it is working (this time)? The technical aims of design and composition can then become wrapped up with ensuring the adequate legibility of the mappings between gesture and effect. This can lead to a neglect of aesthetic issues in two main ways. First, pieces can appear to be no more than demonstrations of human-computer interaction. Second, and for me more importantly, pieces may not actually be the vehicles for developing a critical aesthetics of interactivity their composers would hope. If effective (for the performer) interaction takes place legibly (for the audience), a piece's concerns can lie elsewhere (e.g. it can be about gender or ethnicity) – it just happens to be (fashionably) interactive. Ironically, the more well engineered the interactive solution and the more attention is paid to ensuring that the chosen solution can be decoded by audience members, the less interaction can present itself as the piece's problematic. Clearly legible interactive works – once the audience solves the puzzle, or the performer is well enough rehearsed – phenomenologically cease being 'about' interactivity.

The argument is that, in much interactive computer music research, certain design preferences act together to inhibit interactivity itself becoming an aesthetic topic. The centrality of the 'live processing' register of performance, composition and design strategies which map interactive gesture to computer generated parts on a per piece basis, an over-concern for interactive gestural legibility and so forth can all hang together to make interactivity more a technical problem than an arena for aesthetic enquiry. A research strategy which negates some of these preferences, or at least contextualises them in relation to their opposites, seems called for. There follow four specimen features of such a strategy. These features serve as an introduction to the specific designs which follow later in this chapter (when I have been able

to work them through) or as placeholders for future work (when I have not).

Synthesis First

My design work has prioritised looking at sound synthesis and, in particular, developing interactive techniques which vary the performer's gestural relation to what is heard (it is these techniques rather than any innovation in synthesis per se which I will go on to report). My strategic aversion to 'live processing' as a way of realising improvised electro-acoustic music is geared to avoid any fixed relationship between musical resources or performers which might dominate what could otherwise be variably explored. It does not seem idiomatic for my design work to fix the sociality of performers (one supplies sound, the other processes it, cf. the 'default' set-up of the Evan Parker Electro-Acoustic Ensemble) when how that might vary is what one is interested in exhibiting. I have recently begun to look at live processing but with an emphasis on techniques which allow the variable coupling of acoustic and electronic materials, as well as giving the performer of the software some independence in the sourcing of sound. My synthesis control strategies and ideas for live processing are discussed through software examples in the next section.

Explore Dull and Deviant Devices, Infra-instruments and Restricted Technique

If the concern is to thematise human relations with musical machines in performance, there is no need to make the computer disappear into a bespoke interactive device. My devices are on a table and on show. I do not avoid using conventional commercial controllers (turning dull devices...) as their data can always be remapped in various provocative ways if required (...into deviant devices). Knobs, sliders, keys (both qwerty, and ebony and ivory), mice, joysticks, touchpads and so forth should be exhibited and not hidden.

I also have a strategic aversion to so-called hyper- or meta-instruments. Commonly, design and research endeavours bearing such prefixes are in the name of augmenting virtuosic playing of a traditional instrument with additional control over computer generated contributions (Tod Machover is quite clear on this 'new virtuosity'). The virtuoso-control pairing is a very particular interactional schema. To reorganise the research agenda, I would like to suggest playfully yet seriously that we could explore infra-instruments. Just as 'infra-humans' don't quite make it to be human, infra-instruments have some failing which might make a player's efforts to engage with it be of interest for exhibiting variable interactivity. By contrast with the extended techniques some improvisors use (e.g. the circular breathing and multiphonics of wind players), infra-instruments are played with restricted technique (e.g. I slacken electric guitar strings to give a one-handed non-sustained technique to allow my other hand to be engaged elsewhere, see Chapter 2). In future work, I hope to say more about these proposals and allied design ideas for experimental musical instruments.

Resist the Dogmas of HCI, No Matter How Visionary or Well Meaning

A few years ago, Negroponte and Shneiderman engaged in an academic controversy over interaction design (see their contributions to Bradshaw 1997). For Negroponte, future

computer use would see increasing deployment of ‘software agents’ to whom information gathering and presentation services could be delegated (e.g. a virtual butler who knows one’s every need). Amongst other developments, speech interaction technologies would make conventional input device and graphical user interfaces (GUIs) things of the past. Shneiderman, by contrast, sees the opportunity for ‘direct manipulation’ given by GUI technology as important for giving users a sense of control and responsibility for their affairs which would be forfeited if we dangerously delegate to software no matter how agent-ful or human-like it seems.

Like many of the disputes we have encountered, these oppositional concepts (software agents versus GUIs, delegation versus direct manipulation) become dogmatic when abstractly debated. There are many different relationships between human and machine which are glossed over in the term ‘interaction’. To be sure, we can conceive of *delegating* to a machine enabling it to engage in some computational task while we do something else, rejoining the process later to inspect results or refine the machine’s activity. In the musical case, I have referred to ‘composition machines’ in this connection in Chapter 2 and some more detailed examples will shortly be given. One doesn’t need to parallel Negroponte’s image of the virtual Jeeves with something as crass as a virtual Mozart to convey the point. Shneiderman’s emphasis on skilful direct manipulation has parallels with *instrumental* interaction as he himself notes. One can note other possibilities. Writers on complex systems like power plants or those in industrial process control often speak of *supervisory* interaction. Through operations at a control room, one might supervise a complex process but it may have its own complex physics or chemistry (in the case of power generation) which one cannot hope to manipulate in detail. In musical cases, a notion of supervisory interaction might capture cases where a complex algorithmic system is overseen in the production of real-time musical material with, perhaps, the algorithm’s parameters being set but its internal operation being autonomous (see Bowers and Hellström 2000). To give a further possibility, writers on virtual reality have claimed from time to time that we are less users of such technologies as, at least potentially, inhabitants within them. The notion of an *inhabited* technically generated environment presents another image of a human-machine relationship. Pressing (1997) reviews a number of lines of research which address questions of sonic interaction in virtual environments from this an related perspectives.

My point is that one should not exclusively side with one of these notions of interactivity over others. They all point to (but do not analyse out) different forms of interactivity. They each suggest different approaches to design but without specifying exactly what is to be built. In the next section, I present a number of software designs tentatively mapped to different forms of interactivity along the lines hinted at here.

Assemble Devices into a Working Performance Ecology

Our discussions in Chapter 2 should make it clear that our ‘object of design’ is not a single piece of technology – neither an instrument, nor a particular piece of software. Rather, to exhibit multiple forms of interactivity, we must deal with an assembly of devices in a performance ecology. I can find very little thinking about this issue in the musical research literature – though Ungvary and Kieslinger’s (1996) conceptualisation of a ‘musician’s

cockpit' is perhaps on similar lines. Published accounts from these authors remain sketchy and programmatic – as I will too at this stage. I have pointed to questions of the local spatial organisation of performance environments within the reach of performers (e.g. the left-right organisation of the table-top or the distribution of channels on a DJ mixer). I have presented examples of how performers establish visual access of each other and use what they see others doing to help them shape the music. I have remarked that technologies can be variously designed and assembled to facilitate this legibility of a musician's conduct. I have noted some parallels with the results from empirical studies in related, though non-musical, contexts (cf. Heath et al. 2002). But a more detailed treatment of all these issues lies in the future. For present purposes, let me note that a consideration of such ecologies would usefully balance the research on meta- and hyper-instruments and the like as this is preoccupied with designing single artefacts rather than the interworking of an assembly of things in a concrete performance situation.

Five Designs

In this section I describe five examples of the software development I have done to support my improvisation of electro-acoustic music. These projects were all implemented on the Apple Macintosh platform using Opcode's MAX/msp graphical programming environment. From a strictly programming point of view, I make no particular advocacy of MAX/msp as the same design concepts could be implemented in other languages. The possibility in MAX/msp of structuring the graphical code to visually portray the organisation of a program is useful in the current context as it facilitates describing what a program (or patch in MAX/msp terminology) does and how it works (in the descriptions that follow, specific code objects appear in bold type in the text, e.g. **groove~**). For these reasons, I also prefer a programming style which brings together functional code and user interface objects in the same window. This should make it clearer how user interaction relates to the code. I also happen to like the 'wires hanging out' unfinished impression this gives. In performance, my table is full of various devices and wires between them. It looks provisional and, indeed, in the next performance there might be different things connected differently. I do not see why my code should look otherwise.

The five projects have been selected from an ongoing corpus of work. I have developed over 90 separate applications in the last three years – most of which can be said to 'work' in some fashion or another. These five have been selected because they most clearly exemplify the design trajectory described above, while enabling me to offer more detailed design concepts along the way. They have all been used in live performance or studio improvisation sessions and, with one exception, are represented in the music that appears on the CD which accompanies this text. I describe each patch in some detail and present numerous screenshots in the Appendix. I intend that my description and the screenshots give the reader enough information to reverse engineer their own versions of the patches if it is so wished. I choose to do this rather than publish the code per se as I believe that the design concepts expressed in the code are publishable (e.g. in this text) but the applications themselves are not at this stage (e.g. many highly specific features appear in the code, objects to interpret input data from my

knob boxes, objects to generate output data for my synthesisers, and so forth). I wish to emphasise that I am not resisting software release out of laziness or out of a concern to protect my secrets. In any software community, the value of community-wide sharing has to be balanced against the need for diversity of offerings and the risk that premature release might be counter-productive. At this stage, I would rather that my code was reconstructed by truly interested persons (if there are any) with their own idiosyncratic (mis-)interpretations.

Let me give an overview using the terms of the previous section:

- Geosonos primarily offers a form of *instrumental* interaction to engage with sound synthesis
- AirMix enables the *supervisory* control of the mix and transposition of sound files
- The Dial also enables one to *supervise* a mix of sound files, but it is possible to *delegate* computing the mix to a variety of algorithms
- The Reincorporation Machine combines features of a *delegated* composition machine with live processing under *supervisory* or *instrumental* control taking raw material from sound files or live input
- InCamera is an application to which one can *delegate* compositional duties to be realised through processing, mixing and spatialising sound files

These applications are presented in turn. As I do so I bring out some more specific ‘design stratagems’. These are italicised when introduced or alluded to. In the section following, the stratagems are collated. Throughout the reader should keep in mind that I am describing software applications to be used in conjunction with a variety of other musical resources (including other applications) in the improvisation of electro-acoustic music. I am not proposing omni-purpose computer music systems. Rather I am using these examples to outline and demonstrate design concepts which are viable for improvised electro-acoustic music under the aesthetic I have been suggesting.

Geosonos

Geosonos, in its various versions, featured prominently in the concerts I have referred to as Version 2.2.2.2.0. In these duos with SOH, Geosonos was my major application for transforming data captured from a 2D touchpad (typically the Korg Kaoss Pad KP-1 though the approach can be modified for similar devices) to control sound synthesis (typically performed on a Nord Modular synthesiser). The application remains my preferred means for working with sound synthesis when I am not going for precise control. It was used in the Z3 improvisation on the accompanying CD. An early account of an initial version of Geosonos was published in the first part of Bowers and Hellström (2000).

The intention of Geosonos is to create an illusion for the performer of an *interaction terrain* on the otherwise featureless 2D touchpad. Design followed a principle of *anisotropy* – that is a given movement-vector at the touchpad would tend to have different effects at different

parts of the pad, in contrast to the isotropic mappings of many commercial continuous controllers, where a movement in a given direction tends to be uniformly mapped within bounds (e.g. monotonically increasing a control value or decreasing it). The interaction terrain of Geosonos is also a shifting one – that is, exactly how the touch data is mapped to control data varies over time. Geosonos is an *adaptive interface* which makes it harder or easier (depending upon a parameter setting) to repeat a past gesture. Geosonos effects *few-to-many mappings*. The 2D pad data can be mapped onto a larger number of controllers by superimposing different mapping functions for each touch dimension. Non-linear functions can be superimposed so that, as the performer's finger moves from left to right for example, one output controller might rise while another rises then falls. On one side of the pad the two controllers will be in a correlated motion, while on the other they will be in contrary motion. These superimposed mappings again add to a sense of an anisotropic interaction terrain with different regions having different characters. Finally, in the later versions of Geosonos, some output controllers can be switched between having their values derived from pad data to being algorithmically generated (*variable sourcing*). This, especially when combined with sustained synthesised sounds, gives Geosonos a *secondary identity* as a 'meandering-drifting' composition machine enabling the performer to engage with other devices while Geosonos still generates material with a starting point related to where the performer left off. Points in between are possible too. For example, some controllers might be derived from performer gesture, some algorithmically generated, some frozen at a last played value, and so on.

Figure 1 displays the 'wires-on-show' interface to Geosonos. Let us discuss some of the objects it contains in greater depth. The **input** object handles the two dimensional MIDI-in data. It is also assumed that a particular MIDI controller value is generated when the pad is touched and when touch is released (on the Kaoss Pad, this is the 'Celeste' controller with values 127 or 0). The **input** object measures touch and non-touch times and uses these to compute an attack-sustain-release envelope (e.g. assuming that slow attacks will follow long non-touch periods). This envelope is used to generate values of MIDI controller 7 after the values are rescaled by a function which takes parameters from a MIDI foot pedal. The function is designed so that, for example, when pedal values are high, they override the computed envelope. This means that extremes of amplitude control are available directly from the foot pedal with the computed envelope being override-able (*override-ability*).

The adaptive mapping of pad data is handled by the two **shiftingLandscape** objects to the bottom left of Figure 1, expanded in Figure 2. One analyses and remaps the 'X' pad dimension, the other the 'Y'. Each stores the most recent pad values which have been received. The number of values stored can be set with a 'memory+int' message in the rightmost inlet. When touch is released, these values are dumped to a **Histo** object which computes a histogram of their frequencies. Its values are normalised (so that the highest frequency equals unity) and then distorted by a power function, whose exponent is supplied through the 'degree of distortion' inlet. These values are then renormalised and stored in the **table** named 'adjfreqs' for 'adjusted frequencies'. The cumulative values of the distribution of adjusted frequencies are then stored in the **table** named 'iomap'. This serves as a mapping function for input to output (inverted in the case of negative distortion values) until it is updated on next touch release. The output from **shiftingLandscape**, then, is a function of the values it has recently received. With a positive distortion index, values are 'pulled in' to peaks in the frequency distribution. With a negative index, values are pulled in to troughs in the

distribution. With a positive index, the touchpad is rescaled to invoke (near) repetition of past values. With a negative index, the touchpad is rescaled to generate new tendencies.

Returning to Figure 1, we see that the values output from the **shiftingLandscape** objects pass into **mappings**. The shifted X value (on the left-hand side) passes through this object unaltered and is used to generate a value for MIDI controller 1. MIDI controllers 2 to 5 can take their values from varied functions of the shifted Y value, or from a ‘drifting’ algorithm, or be kept ‘still’ – depending on the assignments made with the large on-screen buttons. As shown, output controllers 2 and 3 are functions of the shifted Y value, controller 4 is drifting, and controller 5 is fixed. Sinusoidal functions are used to map the shifted Y values to output controllers when assigned. A family of different functions is used, so that if more than one controller is so assigned, different mappings are superimposed. In the example shown, as Y increases, controller 2 will increase monotonically, while controller 3 will increase then decrease over the same Y range. Sinusoidal functions are selected such that the first assignment will get a simple monotonic portion of a sinusoid (a half period from minimum to maximum), the next will get a full period, the next a period and a half, and so on. In this way, a variety of non-linear mappings can be superimposed and flexibly so.

The drifting algorithm is the final feature of Geosonos I will describe in detail. The object at the heart of this, **fnbf**, is shown expanded in Figure 3. This generates an approximation of so-called 1/f noise by treating the current value as a 7-bit binary string and updating the least significant bit on each bang received, the next significant bit every second bang, and so on, up to the most significant bit which is updated every 64 bangs. An update consists in a random coin toss to decide whether the bit value in question will be shifted or not. Compared with a random walk (e.g. as provided by the **drunk** object), this algorithm allows larger jumps. Indeed, larger jumps are expectable in inverse frequency of their size – hence the comparison with 1/f noise. Compared with a random selection from a 7-bit range being made on each bang (e.g. as **random 128** would provide), this algorithm is biased towards smaller transitions. Past values have a constraining influence, unlike the ‘white noise’ of **random 128**, but not so constraining as the ‘brown noise’ of **drunk**’s random walks. Various authors (e.g. Voss and Clarke 1978) have argued for the musical qualities of 1/f noises, though this is a controversial affair (Boon and Decroly 1995). **fnbf** implements an approximation of 1/f noise with an additional feature: the user can force the flipping of designated bits with a ‘flip+int’ message. This means that, if values have drifted into an unappealing territory, various magnitudes of shift from the current value can be instantly forced (*override-ability*). The rate with which drifting takes place is set with a ‘drift period’ value into the rightmost inlet of **mappings**. Of course, this is a quasi-period as the drifting is anything but strictly periodic. The drift period is the time in which 64 bangs will be received by the **fnbf** object, during which the values will typically have meandered through much of the allowable 7-bit range.

Various qwerty keyboard presses are intended to add to Geosonos’ usability in performance situations. Pressing the spacebar toggles between MIDI out messages being delivered on channel 1 or 2. In terms of how I conventionally use the Nord Modular this means moving between the synthesis patch in the machine’s memory location known as Slot A and Slot B. In this way, the performer can have a *variable point of presence* in relationship to sound synthesis as interaction at the touchpad or switching the drifting algorithm influences one

sound, then another. Key presses can load new patches and mute and unmute sounds. A panic button is available: with the press of P, all sounds are muted (*panic button*).

Two Mixers: AirMix and The Dial

In this section I describe two mixer applications developed with the needs of live performance in mind. In common with Geosonos, an approach of *few-to-many mappings* is taken so that, for example, a simple gesture can vary the mix between multiple sound sources in a flexible and responsive fashion. AirMix follows a spatial interaction method where an ‘air joystick’ (e.g. the Macally AirStick) is used to derive two degree of freedom tilt data which control the mix. In The Dial, a single knob akin to a radio dial is used to mix between multiple sources. Also following Geosonos, the functions underlying the mappings tend to be non-linear and are selected so that when superimposed a variety of correlated and contrary motions of mix parameters can be obtained as devices are interacted with. The physical ‘mix space’ (the air, the surface of the pad, the dial’s reach) is again rendered *anisotropic* with different regions having different interactive characters.

AirMix (see Figure 4) was developed as part of my set-up for the Z3 two hour long live improvisation on the Sonic Arts Network’s Diffusion radio show on Resonance FM in July 2002. It mixes four looping stereo sound files with the mix coefficients calculated using the tilt data from a Macally AirStick. The Airstick is a USB device designed for games where the position and movement of a hand in the air is captured (e.g. racket games or skiing simulations). It measures forwards/backwards and left/right tilt. A thumbstick is mounted on the top of the device. This gives the positions of a conventional D-pad (or direction pad) familiar from gaming devices. The thumbstick can be detected as resting in the centre or as pushed towards one of eight ‘compass points’. The AirStick is adorned with numerous other buttons, including a trigger. These are all of a momentary switch character. The position of the buttons and thumbstick, and the magnitude of tilt in two dimensions, can be made available to Max/msp by means of the **insprock** object. Figure 5 is an expansion of the **airstick** subpatch showing how the data from the device is parsed. Note the scalings of the tilt data to obtain values in a MIDI-like range (7-bit). These were arrived at experimentally by analysing the data from the AirStick and trying various operations to bring the values into the desired range. Although it may seem like the integer-divisions lead to a loss of resolution, gaming controllers commonly have only a 7-bit resolution anyway even if more bits are used to encode the values. Here, somewhat idiosyncratically, 16 bits are used to encode 128 possible tilt positions on each axis, with a different encoding for each axis, hence the two different scalings. Ad hoc experiential approaches to scaling and/or data smoothing are typical when dealing with such commercial products as musical interaction devices.

Figure 6 expands the **mappings** subpatch and shows how two dimensions of tilt data are converted into four mix controls. Consider the fate of an input measure of left/right tilt in the range [0,127] in the left inlet (note: the right inlet is identical). The cascading **split** objects connected to the leftmost outlet map this range so that [0,13] yield an output of 0, [115,127] yield an output of 100 (the maximum output), and [14,114] linearly maps to [0,100]. In effect, this mapping creates a fade control with ‘dead zones’ at maximum and minimum. Output values lying in the range [0,100] are later remapped into usable mix coefficients by the **scale**

objects visible in Figure 4. The left-central outlet has a different mapping. The **split**, * and % objects transform the input region [0,100] into a double sawtooth with 0 mapped to 100, 100 mapped to 0, and another maximum in between. The sawtooth creates areas of great mix volatility where a mix coefficient can change from maximum to minimum with a small change of tilt. The region [101,127] is another ‘dead zone’ at 0. Considered together, values from the leftmost and left-central outlets describe a complex cross-fade pattern as the AirStick is tilted from left to right. The combination of this with a similarly varying interpretation of the forwards/backwards tilt of the AirStick creates a very varied, anisotropic mix space with a number of *volatile edges*.

Referring back to Figure 4, the thumbstick position is used to calculate the relative transposition of the four sound sources. When the stick rests centrally, all sources are played back without transposition. Rotating the stick clockwise introduces progressively more divergent transpositions. The transpositions are calculated to contain ‘fifths’ ratios – hence the * **1.5** and * **.67** objects (*crude but generally usable relationships*).

Supervening over all this control of mix and transposition are the actions of the AirStick buttons. Tilts and thumbstick movements will only have the described effect if the trigger on the AirStick is depressed, otherwise values will be held. This enables a particular mix and set of transposition relations to be ‘frozen’, for example, while the AirStick is moved to a new orientation (*allowing time-outs*). The buttons on the top of the Airstick labelled A, B, C and D mute and unmute the corresponding sounds on successive presses, the **sel 1** objects beneath the **airstick** subpatch converting the momentary-switch character of the AirStick’s buttons into latch-switches for the purposes of the application. Finally, squeezing the buttons below the trigger on the AirStick will generate various boosts and cuts in global amplitude including a cut to silence (*global immediate effects, panic button*).

The Dial (Figure 7) was developed as part of my performance environment for the show of the same name, a two hour solo improvisation on the Sonic Arts Network’s Diffusion radio show on Resonance FM in June 2002 (cf. the edit on the accompanying CD). It was also used in the Mestre performance described in the last chapter. Up to ten stereo soundfiles can be mixed by means of a single knob which is intended to act in a manner reminiscent of traditional radio tuners (*idiomatic interface metaphor*). The knob navigates a mix space (or ‘wave band’ in the radio metaphor, see Figure 8) in which ten ‘channels’ are positioned one for each sound file (actually 14 are shown in the figure, this anticipates four additional channels of synthesised sound being incorporated into the design). The regions in which the channels will be ‘picked up’ and contribute to the mix are highlighted. This enables channels to overlap. The centre position of each channel is defined in a configuration file which can be loaded into the **coll** named ‘bands’.

The configuration file also contains entries for the total range of the channel (i.e. over how much of the mix space will it be ‘receivable’). An inner range typically smaller than the outer range can also be defined. When the dial position is within the channel’s inner range, the corresponding stereo sound file will contribute to the mix with a mix coefficient of unity. When the dial is outside the inner range but within the total range, an interpolation is made to calculate the mix coefficient. Thus, sound fades out as the dial passes out of the inner range and then out of the total range.

The relationship between inner and total ‘reception’ ranges is also used to spatialise the sound files in the mix using a balance coefficient. When the dial is in the inner range, the balance coefficient is 0 and left and right channels of the sound file are mixed directly to the overall left and right channels respectively. When the dial is to the left of the inner range but still within the total range, a negative balance coefficient is calculated with a value of -1 at the extreme of the total range. With a negative coefficient, the sound is balanced so that the stereo image is narrowed and panned to the left. As the dial moves progressively to the left, the sound fades, narrows and pans left. When the dial is to the right of the inner range but within the total range, positive balance coefficients are calculated – with a sweep of the dial making the sound fade, narrow and pan right. The code which accomplishes this is shown in Figure 9. By careful positioning of reception ranges, a variety of mix effects can be achieved with dial movement: sudden entries of sounds (e.g. if inner range and total range are coextensive), gentle cross-fades (with successive sounds moving in the stereo image ‘out of each other’s way’), interchange between sounds over an extended background (e.g. by having a number of files stretch across the whole dial). Artfully constructed configuration files can create an appropriately *anisotropic* interaction space out of single knob movement. Note also how in Figure 8 a ‘dead zone’ with no channels exists to the right of the dial – for silence (*panic button/knob*). Sounds can also be selected so that related sounds appear in similar dial regions or are kept separate depending on the desired effect. And so forth.

The Dial is designed to work with the Doepfer Pocket Dial, a knob box containing 16 rotary encoders. Two objects at the top of Figure 7 parse and scale the output from this box. Knob 16 is used for ‘tuning’. The others are used for transposing the playback rate of the files and controlling effects on the overall mix. A final feature is worth noting. The object **dialdrifting** automatically moves the dial position. The three toggles above it switch on random generators – one can select between white, brown and 1/f style noises (using **random**, **drunk** and **fnbf**) or a mixture. This gives The Dial some crude composition machine features as the dial position can have an algorithmic source (*variable sourcing*).

The Reincorporation Machine

Earlier I argued against according ‘live processing’ any special status in organising design work for improvised electro-acoustic music. Live processing performances tend to fix relations between performers and between musical materials in ways which the aesthetic I have been outlining would like to leave variable. Live processing performances can fall into various recognisable ‘degenerative states’, for example: an overuse of (short) delay-based processing, too obvious statement and variation or call and response musical structures, the source instrument leading with the processed treatments following, the source instrument dominating larger formal changes, and so forth. However, are there design strategies which might help avoid these problems? In Chapter 2 I described a performance with Ed Kelly in which we explored the live processing of my electric guitar playing. Both Ed and I could process the source sound, though specific features of Ed’s live sampling software constrained his contributions when I was deploying sustained guitar textures. There is a hint here that a principle of source-processor reciprocity might help so that all parties can (variably) act as source or engage in processing whatever is on offer. The Reincorporation Machine (see

Figure 10) offers a further approach inspired by the theatre improviser Keith Johnstone (e.g. 1999) who advocates the value of continual reincorporation of past material from the into ongoing contributions. Johnstone depicts the good improviser as one who is always attending to what has happened rather than one who seeks to direct the future course of the action in a certain way in the hope that others will fall in line.

At the core of The Reincorporation Machine is an extremely large digital audio buffer for capturing live sound. I tend to use about five minutes and capture sound on two channels. Live sound can be switched into the buffer or bypassed. The buffer can also be pre-loaded with any soundfile. The user of The Reincorporation Machine has access to whatever is in the buffer and does not have to accept a fixed delay time. Material is retrieved from the buffer in relation to a 'reference point'. This moves through the buffer at a variable rate controlled by the **phasor~** object and a series of up to six layers of the captured sound play from this point (within the **poly~** object). The layers involve 'splices' from the buffer of unequal length. Prime numbers ratios are used to ensure that the layers do not too noticeably coincide (*crude but generally usable relationships*). The tunings of the six layers can be set with respect to each other as can a global transposition of all the layers. The tuning of the layers works by defining an overall interval in which the layers equally divide. This can enable recognisable octaves and fifths to be found amongst other intervals. A fine tuning randomisation further shifts the tuning of the layers. With low values one has a sense of the distribution of tunings following a 'scale', with high values the sense is disrupted and pitch shifts seem random in the range. In this way, a variety of pitch relationships can be explored using only 2 or 3 controls (again: *crude but generally usable relationships*). Once a layer has played back a splice it returns to the reference position and starts playing another one. In the meantime, of course, the reference position may have advanced and the layers will advance in turn cascading over each other as they progress through the buffer.

The performer can set the lengths of the splices. If the splice lengths are small (i.e. <70ms) a reasonably good quality time-stretch occurs. The transposition is set independently of the splice length and rate with which the reference position changes, so pitch-shifts are independent of time-stretches. If the splice lengths are longer, one obtains looping, 'phasing' and other repetition-and-variation effects. The Reincorporation Machine has been designed to allow *extreme control variation* (also *global immediate effects*). Splice lengths can vary from 0.1ms up to the length of the whole buffer. The reference point can advance through the buffer 20 times slower than time at one extreme (i.e. a 20x time stretch is possible) to 100 times faster than time at the other (i.e. a 100x time compression). Extreme time compression yields a gritty granular effect especially when combined with short splice lengths. Extreme time stretches yield textural material and, at the lower limit of the knob control dedicated to reference point advancement rate, the reference point can be stopped and a frozen sound will be heard.

A tap-delay line with feedback can also be added in, again with prime number ratios for the tap times and extreme settings allowed (different ratios are employed than in the determination of the splice lengths – otherwise obvious repetition effects would too readily occur). This can vary the effect from something reverb or flange-like through to a further multiplication of the layering. All this processing is mixed with the current live input into a 'bus' which is 'listened' to by an automatic sampler (**rmSallyBonkersSampler**). This uses

the **Bonk** object to look for rapid onsets. Up to ten such percussive sounds can be captured. Live sampling can be turned on or off and the range of buffer overwrites can be controlled. This means that there is some control over whether a sample is preserved or overwritten. Currently, I have designed The Reincorporation Machine so that the performer can play back these samples from a small MIDI keyboard, the MidiMan Oxygen 8, which has a two octave span along with 11 MIDI continuous controller sources (a data slider, a pitch bend wheel, a modulation wheel and 8 knobs). The keys are mapped in an unusual way to avoid sample transposition clichés and allow meaningful ‘cluster chords’ to be played (*anisotropy*).

The rationale behind all this is to avoid delay based clichés in live processing while supporting varied relationships between a source instrument and its player on the one hand and the processing software and its performer on the other. First, I have implemented an extremely long buffer which can be accessed wherever one wants. It can be used as a palette of different sounds with some relation to the source. It doesn’t have to be thought of as a five minute delay line. The contents of the buffer are graphically displayed and the reference point in it can be set by a mouse click on the wave as well as by scrubbing with one of the knobs (not to mention letting it advance automatically at a controllable rate). While the recently captured material is automatically sampled it isn’t automatically played back. This means that the performer who is controlling the processing can derive the material from the source performer but play it in a quite different way. One can also control which sample buffers are overwritten by new ‘impacts’ so as to mix old with new in the sample-palette.

The Reincorporation Machine allows a variety of sound manipulation strategies (even though these are derived from just two basic algorithms – the layering and the automatic sampling) and extreme parameter settings. This permits the sound qualities to become quite decoupled enabling the degree and kind of relationship between performers to be itself a notable and variable feature of performance (*variable coupling of musical streams*). Finally, the software is associated with a specific performance-oriented control device (the mini-keyboard). Although this isn’t the most innovative device possible, care has been devoted to how the interaction with the software works (i.e. most knobs when twiddled have strong effects). In particular, a fairly direct instrumental style is supported for sample playback. This complements the supervisory interactive relation the performer has over the layering-stretching-shifting algorithm.

The Reincorporation Machine has been developed as a live processing tool – in particular for an ongoing collaboration with saxophonist Graham Halliwell (as represented on the accompanying CD). However, it can have a *secondary identity* as a kind of composition machine in other settings. The buffer can be loaded with a pre-existing soundfile, for example, and the production of variations delegated to the pitch-shifting-time-stretching-splicing-layering algorithm. (I sometimes do a demo where I import a 30 second Webern piece, set the splice times to relate to the phrase lengths in the piece, and generate an open-ended John Adams symphony. Note: this is a party-piece though it is tempting to make ironic aesthetic points about Webern’s compact style meeting post-minimalist excess – not my current aesthetic however!)

InCamera

InCamera is an earlier effort to produce a composition machine. This was used throughout the initial Z3 performances as described in Chapter 2. It can be heard in action on the Z3 track on the accompanying CD. Four **buffer~** objects are shown in Figure 11 into which soundfiles can be loaded. A stream of ‘synchronous grains’ (Roads 2002) can be taken from each one with the grain size, transposition, envelope shape and location (grain reference) in the file where it is taken all being controllable. A sparseness control defines a probability that a grain will not sound. Finally, a meander control determines (using **fnbf** pseudo 1/f noise) the degree to which grain size, transposition, envelope shape and location can vary. Values for these four parameters can also be set directly using a touchpad or mouse movements – the 2D data yielding four parameter values through my standard technique of overlaying two functions on each dimension (*few-to-many mapping*). Various qwerty key presses are identified to determine whether particular parameters and/or particular streams will respond to the 2D data. In this way, some streams can be directly controlled while others may meander algorithmically (*variable point of presence, variable sourcing*). Streams can be governed by common or disparate parameters (*variable coupling of musical streams*).

Algorithmic composition based around granular synthesis is not uncommon. Perhaps more unusually I have linked this to an algorithmic mixing and spatialisation technique based around the notion of the streams being diffused in a 2D virtual space (*interaction terrain*) or chamber (hence the name: camera = chamber) Within this virtual space, sources of streams have a position and an orientation. A virtual microphone (or vmike) can be set at a particular location with the mouse or can be moved according to simple circular motion paths using the **orbit** and **rotation** objects. As the vmike approaches a source location in the virtual space, the source will become louder. The relationship between the distance between the vmike and the source and their respective orientation vectors determine the ‘width’ and ‘centre’ of the stereo image projected onto the vmike. Each source within range contributes to the mix at the vmike. The final actual audible mix is given by coefficients calculated on the basis of this ‘virtual sonic geometry’. Through controlling vmike location (orientation is given by the vmike’s momentary displacement vector), one can derive the 16 mix coefficients needed to calculate an 8 into 2 mixdown (*few-to-many mapping*).

Summary: A Small Catalogue of Design Stratagems

In developing my description of Geosonos, AirMix, The Dial, The Reincorporation Machine and InCamera, I folded in a number of what we might call design stratagems. These are principles for the design of interactive musical technologies which have seemed apposite from time to time. They are not intended as universal guidelines but they have been encountered repeatedly in my design work. Some are idiosyncratic and perverse, some may be re-articulations of common software design lore. However, they all contribute to a characteristic design stance for interactive musical technologies for electro-acoustic improvisation. Let me organise what has emerged to serve as a summary of my software design work.

- *From user interface metaphors to spatial interfaces and physical activity.* It is common

for software design influenced by the perspectives in HCI to emphasise the importance of a good interface metaphor for the learnability and ease of use of software. As I have been designing software which has a role in relationship to particular input devices and is intended to be part of an ecology of multiple artefacts, the notion of interface needs to be extended from just what is manipulable on screen (Bowers and Rodden 1993). In only one case is there a clear idiomatic interface metaphor in the traditional HCI sense: the tuner in The Dial. Otherwise my concern has been to create artefacts which engender gestural-physical activity on the part of the performer. Commonly a spatial interaction technique is used – a 2D interaction terrain on a touchpad or taking tilt data as the performer moves a device in the air. This spatial data is scaled in various ways to make the interaction space anisotropic and textured.

- *Mappings and simple device data.* The question of how to formulate mappings from input device data to control data internal to a program is under-explored in any systematic way in the HCI of interactive musical artefacts. Developers tend to follow intuitive approaches which are bespoke for each program. While I am not exceptional in this, I have offered some stratagems to help articulate design options. My approach has been to deal with devices which offer a small number of dimensions of data variation (degrees of freedom) and work with few-to-many mappings. This approach contrasts with research which takes very many measurements of musical gesture and then tries to reduce them. However, the simple device data is made ‘expressive’ by a number of further stratagems: allowing extreme control variation, rescaling data to create adaptive interfaces, using non-linear and discontinuous mapping functions to create volatile edges, working with crude but generally usable relationships.
- *Compositional principles.* I mean ‘composition’ here in the modest sense of ‘how things are put together’ – rather than in any of the grand constructions of music composition we saw opposed to improvisation in some of the literature in Chapter 1. Several of the software designs embody simple compositional notions. The adaptive interface techniques engender music that is variable in its resistance to change or a performer’s ability to repeat. I have worked with independent musical streams (the mixers) or ones which interact to share a ‘common fate’ (the composition machines) – ‘composition by variable coupling’ might be the general concept here. I have also informed design on a number of occasions with simple notions of transposition and scale.
- *Variable interactivity.* As exploring different senses of interactivity is a core aesthetic concern, I have built applications which support instrumental, supervisory and delegated footings between user activity and technical consequence. It has been a particular concern to design applications which have both a primary and a secondary identity so that, for example, instrumental interaction can yield to a more delegated approach without moving between applications. To accomplish this, I have deployed various stratagems: variable sourcing to switch between device data and algorithmically generated values, variable points of presence to vary what is directly manipulated versus what is static or algorithmically controlled, allowing time-outs and supporting easy engagement and disengagement, and so on. A number of stratagems are concerned with the re-establishment of an instrumental intervention after a period of delegated algorithmic control: mappings with global immediate effects and extreme control variation.

- *Risk*. As remarked in summary of my ethnographic reflections in Chapter 2, the existence of a variety of coexisting forms of interactivity in a performance setting can potentially exacerbate intelligibility problems for an audience. Working out what on earth is going on can be a problem for performers too. Some stratagems are devoted to helping manage the risk in complex technically-rich ecologies: panic button, override-ability, global immediate effects and so forth.

Music as Design Documentation

An audio CD accompanies this text. I have selected work in trio, duo and solo formats for critical scrutiny. My intention is that listening to this CD can inform the reader's appraisal of design work described in this chapter, the general design orientation, the stratagems in its detailing, and specific applications in use.

1. The trio piece *Z3three* opens the CD. This is a studio improvisation by the Zapruda Trio. I work with three musical resources in the piece in line with the use of the three channel DJ mixer I describe in Chapter 2: an electric guitar with slackened strings which I stimulate with a small electric fan, Geosonos controlling a Nord Modular synthesiser, and InCamera. The piece is a largely unedited 'desk recording'. I have only processed the recording at the mastering stage to bring its levels in line with the other tracks.
2. A duo piece with Graham Halliwell on amplified saxophone, *BH2*, follows. I work exclusively with The Reincorporation Machine throughout the duration of this piece. Initially, I manipulate two contact microphones to obtain material for the buffer. A few minutes into the piece, I switch to sourcing the saxophone. Again, this is an unedited desk recording. Much of our playing on this track is at quite a low level so I have worked with noise reduction to optimise its quality prior to level maximisation for mastering purposes.
3. The CD closes with an edit of the solo radio show, *The Dial*, I did for the Sonic Arts Network's Diffusion programme on Resonance FM mentioned earlier in this chapter. As I had two hours of recordings from this show, my editing has been rather more extensive. This third track, which I have named *The Dial, Touched*, is organised around four excerpts from the show with three bridging passages. The excerpts have been chosen for their representative documentary value, not necessarily because I feel they were the best things I did. Rather they manifest certain points which are relevant to the design of The Dial mixer software which I use throughout, as well as informing discussion of my electro-acoustic improvisation in solo settings. Two of the bridging passages are soundscape material initially recorded binaurally using ear-microphones. These two recordings were played in the show but appear in this track from source, rather than via the Resonance FM recording. The third bridging passage is a micro-composition of soundfiles which were taken to the studio but happened not to be played. It is included for reasons of perversity – a piece made of sounds which were not heard and assembled in a manner which was not typical. *The Dial, Touched* makes for a number of contrasts with the other two tracks, a technical one I will mention here. The resonance FM recordings were extremely compressed for broadcast purposes. The relative loudness levels of *The*

Dial, Touched after the duo work with Graham Halliwell may surprise you. You have been warned.

Commentary

I want to discuss the music I have presented from a particular, and perhaps unusual, perspective. Let us treat the music as a trace of software in use. That is, the music is documentary evidence of how certain design decisions, as embodied in artefacts, have been worked through. On this view, the organisation of the music instructs us in how we should appreciate the designs presented above. Together with various ethnographic details, we can use the music to reconstruct what occurred and practically appraise the value of the design work. Let us examine some sample features and episodes.

Early in *Z3three* a spacious sound can be heard enveloping more foregrounded contributions. It has a noticeable attack but then makes a transition with a slight pitch sweep and reverberant tail. It is heard several times in various levels of prominence in the mix and with different spatialisations. This sound is supplied by InCamera. The granularisation parameters were set to extremes so that, effectively, the whole of the source sound file is heard. The variable mix and spatialisation reflects the operation of the virtual microphone concept in the software as described above. Although with extreme granularisation values the source soundfile is looping, enough variation is being produced to ensure that this is not tiresome. A single hand can rest over a fader on the DJ mixer to balance the contribution of the sound with those of the others. The other hand, after some brief work on the touchpad driving Geosonos, can reach for the fan to stimulate the strings of the electric guitar. At the outset the volume pedal is at minimum. Once the strings are vibrating, I can pull my foot back on the effect unit's volume pedal and bring the guitar into the mix. I slowly swell the guitar sound and find that it makes a stark contrast with the existing sounds in play. I cut the sound and, after a pause, swell it again – all the time looking after the contribution of InCamera with my free hand. After this repetition, I pull back the volume pedal before starting to make the strings vibrate only to find that the magnetic field around the electric motor is inducing sound from the guitar pickups without me making contact. I repeatedly fly the fan in the vicinity of the guitar and away. SOH finds a sound to enter into dialog. I bring down the contribution of InCamera by flipping the cross fader but a minute or so later, when SV is playing some aggressive percussion samples, I flip the fader back over to find the InCamera contribution able to provide a reverberant tail to one of SV's impacts. In the last half of the piece, I am principally occupied with putting sudden bursts from the Geosonos controlled synthesiser and impacts from the guitar into relation with similarly aggressive contributions from SV and SOH. I have a working performance ecology in this piece. The music may not be beautiful, my contributions may not be the best one can imagine, but the technical provision for them is adequate for my sustained viability and contribution as a trio member.

The episodes extracted from *The Dial* radio show are rather differently organised. In most cases, the music is made of concurrent layers. I relied quite extensively on playing back recordings of improvisations (e.g. featuring clarinet and bugle) alongside synthesiser work and the operation of The Dial software. Sometimes there are three or four layered sources and in the case of the software contributions these can be layered still further if more than one

soundfile ‘channel’ is ‘tuned to’. Interaction between events in the layers is accidental and local. It does not have the cumulative effect of one person acting on another’s contribution to engender changes between passages of a different character as occurs in *Z3three*. The music is more ‘blocky’ and ‘episodic’ – even before I attack the show recordings with my digital razor blade to make the excerpts for the current CD. I am not necessarily saying this is bad music. I find much of *The Dial, Touched* interesting because of its material heterogeneity: soundscapes, synthesiser drones, vocalisations, acoustic instruments, radio sounds are all in play. I also don’t mind music composed of loud, compressed blocks of sound. However, the sounds here don’t have a responsivity the one to the other – except accidentally so. The presence of very noticeable loops adds to this impression. In the practical production of this music, in my solitary activities in the lonely studio in Denmark Street, I am delegating the production of the music to various machines (mini-disk recorders, The Dial, a theremin, a radio, a synthesiser) and supervising their mix. In the details of their productions, though, they remain independent of each other and I can only grossly make them interact – through triggering and fader flipping. The result: a materially variable music but with less variable traces of interactivity. The Dial fits in with this picture with its layered independent ‘channels’ and uniform interaction technique – twiddling the ‘tuner’.

The collaboration with Graham Halliwell is of a yet third order. I contacted Graham with the express wish to explore more spacious, less hyperactive forms for improvisation than some of my other work. The Reincorporation Machine’s design features allow me to vary the coupling of my contribution to Graham’s in quite radical ways. Sometimes I am using long splices from the buffer to hint at an ‘orchestra of saxophones’. Othertimes, I am able to use extreme settings to generate highly electronic material. The use of the contact mikes gives me other options as well – for one thing I can start the piece on an equal footing with Graham, I do not have to wait for him to give me some material to go on. I can create both sustained textural and highly punctate events, rhythmic and arrhythmic productions. I can leave the layering-stretching-shifting algorithm to do compositional machine duty, while I explore the percussive contents of the live samples. The pacing of the music allows me to make considered choices about what to do next. While the software often leaves the performer uncertain as to what in detail will happen (what exactly is under this keyboard key? what exactly has the automatic sampler found?), if a particularly desired acoustic sound is heard to enter the buffer (and seen on screen), the mouse can be positioned over the relevant part of the buffer’s graphic and the sound found for reincorporation. In terms of the aesthetic and design goals discussed at the outset of this chapter, I find the greatest variability in the sociality of improvisation found in *BH2* over the other recordings: from independent layerings to a flurry of dialogic exchange towards the end. The materials are constrained. It is after all just saxophone, electronics and a pair of contact mikes being rustled in the hand and against one another. But within this reduced sound world, we do our best.

Next Steps

I have set aesthetic aims which valorise the exploration of variable interactivity, materiality and sociality between performers so as to make varied human-machine relationships exhibitable. If music is produced which falls short of these aims, then the circumstances of its

production need to be scrutinised to determine sites for improvement. In the cases of the duo and trio work, I find the music to be adequate to the aims, and the practices of its production to be viably organised around useful software and an ecology of interaction devices. In the case of the solo work, I am not so sure. While it is a recognisable music of a certain layered and blocky form, it doesn't consistently manifest the features aimed for. Partly this is due to it being a solo production: my 'simulations of sociality' are ineffective. Partly also this is because I am aiming for density and activity without having the resources for supervising it. In this context of use, one can scrutinise the design of The Dial software: its relatively independent mix channels do not support variable relations between contributions. Interestingly, The Dial worked very well when performing in a duo with SOH at Mestre (see Chapter 2). Its degenerative states (g-loopiness, non-interacting layers) did not impact upon the music in the same way. This is probably because, with four hands working the music, The Dial was not left running autonomously so prominently so often.

These analyses and commentaries are beginning to suggest a future agenda for ethnographic reflection and design. The work in Chapter 2 prioritised the examination of collective improvisation settings even if my individual phenomenology and working activity was given most attention. Duo and trio work overwhelmingly accounts for my public performance opportunities and the aesthetic I have developed is critically concerned with the sociality of electro-acoustic improvisation – even if I see that sociality in idiosyncratic ways. My design work has concerned the construction of 'personal software' and devices for use in a performance ecology within my arms' reach. But it is an assembly of artefacts and practices for making me a viable participant in collective music making. I feel I am yet to formulate effective practices and technologies for solo work.

There are two possible directions here. One is to follow the example of the duo work with Graham Halliwell, here heard on *BH2*, and investigate a more 'reductionist' improvisation style while still following my interest in heterogeneity of musical materials. The reduction would have its 'level' set by the organisation and pacing of my instrumental, supervisory and delegational acts, and their relationship to the sense of activity in the music. I am anticipating a music with a practical-interactional pacing that is calibrated for my two hands. This need involve no new software development, just more appropriately paced workings with existing ecologies.

The alternative direction is (crudely expressed) to build better composition machines – ones which are more effective delegates of musical activity – and/or explore non-supervisory interactive relations. Let me explain a little more what is intended here. I have described InCamera as a compositional machine based on granularising four streams of sound and mixing and spatialising them algorithmically using a virtual mix chamber concept. In *Z3three* I found its mixing and spatialisation strategies working rather well while it was minimally supervised by a hand controlling its amplitude. Its granularisation techniques are not so effective. Indeed, a number of programmers have encountered problems working with granularisation on the MAX/msp platform (Tutchku, personal communication). InCamera's granular effects are rather like The Dial's gloopiness. One has to intervene more often than one would wish because their productions become a bit too predictable and recognisable. In solo work, this can be more than two hands can manage.

As a technical alternative, the layering-stretching-shifting algorithms of The Reincorporation Machine provide an alternative to InCamera's implementation of granularisation which can be investigated in future solo work. There are other technical possibilities too. Figure 12 shows the main window from an in-development project which revisits Lyapunov's Tonic (the algorithmic mixer/composition machine mentioned in Chapter 2). Six stereo sources can be mixed. Two of these are loops which are intended for background textures or the replay of long files whose looping might not be obvious. The interest lies in the other four channels which are mixed using the non-linear mappings of AirMix. Two of these channels use an object called **xChainingObj~** which is expanded in Figure 13. At the top right of this figure is some code which measures the amplitude (using **peakamp~**) of the signal generated by a mix of two **groove~** sample replay objects to the lower left. This amplitude is smoothed by an IIR-like filter defined by the **expr** object. When the smoothed amplitude lowers below a threshold, a trigger is generated. This trigger initiates a cross-fade between the two **groove~** objects. The intention here is for portions of soundfiles to be identified and excerpted in a fashion which is sensitive to their internal organisation (at least as revealed by their amplitude profile). In contrast to most granular methods (see Roads 2002), I am not imposing an arbitrary envelope onto the excerpted material. I am detecting transitions in the file's amplitude and using these to trigger finding the next excerpt. The **logisticSelector** object uses a non-linear and potentially chaotic iterative function to select the next sound from a range of pre-loaded files. In this way, the sounds which are selected for amplitude measurement and excerption are themselves varying. This is a much more flexible technique than InCamera's use of four fixed files for granularisation. The limits on the number of sounds which can be pre-loaded and made available to the **xChainingObj~** largely derive from the memory limitations of the host machine. A number of real-time controls are available to shape sound selection – how many sounds can be selected and how chaotic is their selection are just two of the parameters. This can create rhythmic effects as we move between different sound files with the non-linear selection function in a periodic region or a more unpredictable shuffling if the selection function is chaotic. Another real-time control approximately sets how long the excerpts will be – approximately because excerpting is always done in a fashion which is sensitive to the internal amplitude envelope of the source material.

The output from each **xChainingObj~** is listened to by a live sampler in the manner of The Reincorporation Machine. In that program the samples were played back directly (instrumentally) from a MIDI keyboard, here an algorithmic solution is adopted. Figure 12 shows two objects with **sallyBonkersPlayback** at the root of their name. These contain non-linear iterative functions which control the selection of the samples to playback, their timing and transposition amongst other features. Again, the intention is to make for a highly flexible arrangement with a variety of rhythmic and textural outcomes being possible. Each algorithmic **sallyBonkersPlayback** channel is coupled to its **xChainingObj~**. This enables a variety of relationships between 'original' and 'live sampled' material to be played with. The live sampling occurs automatically and regardless of the setting of the associated **xChainingObj~**'s fader. This means the sampled and algorithmically 'sliced and diced' playback can be introduced *before* the listener hears the 'original' if desired.

This revisiting of Lyapunov's Tonic introduces a variety of 'second order' features to the algorithmic organisation of its compositional strategies. While InCamera mixed granularised soundfiles, Lyapunov's Tonic works on streams of excerpts taken from (potentially and

controllably) multiple files. Changes can be introduced in the music at several levels: how sounds are selected, how excerpts are chained together, as well as how this is sampled and played back, alongside the relative mix of all these components. With just static control settings this application works more effectively as a compositional machine than InCamera. The next step is to investigate techniques for getting those controls (currently manually set using the Doepfer Pocket Dial, see the relevant objects in Figure 12) to change in an engaging fashion algorithmically (and thereby manifest ‘third order’ features of variation). The aim is to create a composition machine that can be more lightly supervised than The Dial or InCamera in solo settings, one that needs less frequent rescuing from degenerative states.

A further technical alternative was hinted at above: explore alternatives to supervisory interaction. Many of my software projects involve some form of supervision on the part of the user. Algorithms determine the detail while the user has real-time control over their parameterisation – in Bowers and Hellström (2000) we called this ‘algorithmically mediated interaction’ and made contrasts with both software agent based interaction and direct manipulation in HCI (cf. the discussion of Negroponte and Shneiderman above). Earlier we introduced, via a brief discussion of virtual reality, a notion of machines synthesising virtual spaces for musical interaction with performers being ‘inhabitants’ within them. I have preliminary work, which I intend to refine in the future, with this kind of footing for interaction. In one project at an initial stage, the performer’s actions are regarded as displacements in a multi-dimensional musical space. Within this space are ‘artificial actors’ who might be attracted or repelled to the virtual locus of the performer. The activity of the artificial actors is sonified. In another preliminary project, the performer’s actions are listened to by a number of artificial actors who, if they are ‘interested’ in what the performer is doing, create variations upon it which they ‘play’ – these variations can then in turn be reacted to by the performer or the other artificial actors. Figure 14 shows the main screen of this latter project, The Improvisation Machine. I am aware that these approaches, to the level of detail I have given, are not novel – George Lewis’s *Voyager* is a well-known algorithmic improvisation system structured on very similar principles (though Lewis has not published an extended technical description of how *Voyager* works). Indeed, I am also aware that I seem to be reneging on the opposition I showed earlier to pieces which are organised around algorithmically generated accompaniments to live playing. Much depends on the details of how exactly these ideas are worked with and the performance context in which they are designed to fit for one to properly assess research novelty. What ‘model’ of improvisation is built into the artificial actors? How might an improvisation machine – apparently designed with simulation-reification in mind – fit into the heterogeneous performance ecologies I have been at pains to promote? These are the core questions for this endeavour needing answers to set my designs apart from others. I hope earlier work in this chapter has given a hint of how I might proceed.

To conclude this discussion of ‘next steps’ with regard to technical design, let me emphasise again that – in spite of the extended attention I have just given to new software projects – this is just one part of the work to be done. The other part is continue to refine the overall definition of practices for improvised electro-acoustic music making whether they depend on new software projects or not. I do not believe I have extracted all of the goodness out of existing applications and some are better positioned in duo and trio than solo settings. Working out what works when is all part of the design of musical interaction in the larger

sense. Furthermore, there are arguments for a ‘musical reduction’ in (especially) my solo work which might find expression without further technical innovation (of course one might want to innovate for other reasons – there is no contradiction here). I think the essentials of the design orientation I have worked through in this chapter are basically sound. I have moved between different relationships between design and my ethnographic accounts of performance experience. While much of my design work is under the rubric of ‘meshing-mediating’ to create working performance ecologies which are viable for the exploration of a defined aesthetic of human-machine relations, I am prepared to entertain (tongue-in-cheek) ‘simulation-reification’ approaches and have begun to prototype ensembles of artificial electro-acoustic improvisors. Design has a flexible footing in relationship to ethnographic background. I sketched a number of priorities for design by contrast with much existing ‘computer music’ research. Again, I think these priorities are sound, though I am not treating them dogmatically. Finally, I set about designing a set of software applications which address different senses of interactivity and embody a variety of different design stratagems. Yet again, I feel that this is productive of interesting and usable software which allows me to make some progress in exploring the aesthetic of machine music which concerns me.

Instead of a Conclusion:

Dead Ends and Red Herrings, Loose Ends and Tie-Ins

It is time to draw the current investigation to a close. While we have been single-mindedly concerned with musical improvisation, we have taken in a variety of perspectives on the topic and offered a number of contributions. Initially, we were concerned to sort through some of the notable positions that have been taken on improvisation amongst several celebrity composers and critics – especially those who wish to fashion an oppositional construction of composition/improvisation. We turned our attention to writers who attempt to establish a location for improvisation in the political economy of music. We examined those who work with highly inclusive concepts of composition, improvisation and performance. Against this literature, an ethnographic turn was offered for consideration. We should treat ‘improvisation’ as a member category and examine its significance in the hands of those to whom the notion makes sense. We considered a variety of the world’s musics from this standpoint before making a detailed examination of recent musicological work on jazz and finally turning to questions of technology in improvisation. Having cleared the way through musicological review, an extended ethnographic treatment of the author’s concert experience as an improviser of electro-acoustic music was presented. On the basis of these empirical observations, a practical agenda for studying electro-acoustic improvisation was presented. We were concerned with the intimate ties which interlink technical interactivity, social interactional relations between players, place and occasion, and so forth into contingent practical configurations within which musical forms should be understood to emerge. We gave special discussion to the observable variations in forms of technical activity, social interaction and musical material which exist across the various performances which were documented. This variation, far from being a source of deviation or impurity to an artistic conception of the ends of improvised electro-acoustic music, was offered as informing a musical aesthetic specific to investigating contingent human practice in a machine world.

After a discussion of the various ways in which ethnographic work might motivate technical design, this aesthetic image was put to work in reshaping research agendas for music technologies. We examined different interactive relationships that performers might have to software technologies and presented a number of demonstrator applications which have been used in performance by the author. Along the way, a series of subsidiary design stratagems was offered. Three pieces of music involving the author were discussed for their effectiveness in pursuing the aesthetic image that had been outlined and the author's use of the presented applications was discussed from this perspective. On the basis of this, a variety of strategies for future work was discussed – not all of which involve further technical developments, some involve rethinking the kinds of musical practices the author wishes to engage in while pursuing an aesthetic investigation of human-machine relations through improvised music.

While this work started out with a consideration of improvisation as a general musicological concern, it has been at pains to recognise and isolate the specificity of different improvisatory practices. It is important that we do not overstate what we have achieved in understanding electro-acoustic music from this perspective. While we have offered a potential aesthetic of improvised electro-acoustic music which makes sense of its specific nature as a machine music performed before your very eyes, we have not presented any formal details of what might be musically-formally-organisationally specific about music done this way. The current work has not presented transcribed examples of musical interactivity for analytic scrutiny. While it is suspected that improvised electro-acoustic music – especially when performed under the aesthetic we have discussed – may have specific formal features worthy of note, this remains undocumented. The empirical strategies of the current work are limited in this regard. Ethnographic accounts of concert experience have been reported so as to inform technical design practice. However, a proper formal understanding of the organisation of improvised electro-acoustic music requires other methods. The author has begun collecting concert videos for more detailed analyses of the real-time production of electro-acoustic improvisation but the results of such analytic work lie very much in the future.

I have flirted on a few occasions with concepts which might help us analyse improvised electro-acoustic music as a formal musicological phenomenon but in ways which are consistent with the ethnographic orientation I promulgate. In Chapter 2, various theoretical concepts in electro-acoustic music (e.g. Snalley's spectro-morphology) were scrutinised from the point of view of music as a real-time contingent accomplishment. I wrote about the characteristic 'immanent structures' of such music, how it might be interactively fashioned out of 'threads of significance' as musicians react to each other's productions. Clearly, all this could be related to fashionable musicological discussion of form and narrative in electro-acoustic music. Elsewhere, in the current chapter, I have discussed how the variable pacing of a performer's instrumental, supervisory and delegating acts might interrelate with the activity of the music so produced. Again, there is a hint here of concepts and analytic orientations for the musicological analysis of improvisation. Furthermore, it would be promising to revisit some of the notions introduced in Chapter 1 for getting to grips with 'non-idiomatic' improvisation. Parker's notions of laminal and atomic improvisation, their relationships to different musical materials and forms of interactivity should be cashed out analytically in future work.

As it is, I do not feel that the current research is without musicological weight. To my

knowledge, the current study is unique as a participant-observation study of the practice of electro-acoustic improvisation. The focus of the work, however, has been to use such research to inform design. I am yet to fold its results and perspectives back to larger musicological issues. In Chapter 2, I gave some hints as to how my account of the practical contingencies in music production might relate to discussion of the ‘extra-musical’ and other such matters. But this and other potential contributions to a worldly musicology in the tradition of, say, Blacking (1995) or Small (1998) have not been played out in depth.

I have put a number of other topics on the research agenda without fully delivering on them. Persistently, I have argued that we should examine how performers manage ‘assemblies’ of artefacts and work with ‘performance ecologies’. These are notions in need of further illustration and concerted design attention. While we have offered designs stratagems for the construction of software artefacts, we have not done parallel work to guide how such artefacts might be assembled with others or be blended in with quite different instruments and devices. Chapter 2 offers some starting points – the left-right sense of what is within reach to a performer, what a performer can pick up of the activities of others, how a performer can project their own activity so that others can become aware of what is going on, how a heterogeneous set of technologies with different forms of interactivity might relate to all this – but these name research issue not findings, topics for investigation not designs successfully accomplished. The current work has been partial towards computational technologies and their design. It has not given a symmetrical approach to the physical-manipulable constructions I have worked with and, in some cases, made (e.g. the Strandline guitar, the Mixing Bowl). While these artefacts have a degree of humour about them, they are nonetheless serious contributors to the heterogeneous mix of resources I wish to advocate. To properly inform questions of the design of performance ecologies, one would need to consider the design principles for such physical-manipulable acoustic and electric artefacts and instruments and see how they relate to computational technologies.

While there is clearly much work to do, I hope I have given an impression of a coherent programme for the practice of improvised electro-acoustic music – one which combines analytic, reflective, aesthetic and technical design elements, and is of potential musical, musicological and technical value. The pursuit of such an interdisciplinary and practically situated programme is, to me, vital. The stakes are high. We have forms of music, which are recognisably emerging, in need of an understanding. We have technologies in need of creative appropriation. We have performance practices in need of reflection and refinement. From time to time, we might even have audiences who could get pleasure from this music of howling synthesisers, scraped metal, wheezing wind instruments and Stan Getz samples. Who knows?

Acknowledgements

Naming individuals for thanks is often a problematic affair as one feels a need to be exhaustive or else anticipate offence if someone is forgotten. So let me start with: I profoundly thank all those who are unnamed in the acknowledgements that follow, especially those who feel offended by your omission. Without you, none of this work would have been possible. As for those parties who happened to be picked out ... I thank the staff and students of the School of Music at the University of East Anglia, especially Simon Waters who has infuriated and inspired me in equal measure which I guess is just about the right mix for a supervisor. I thank all the musicians I have played with in the time of conducting this research, especially Sten-Olof Hellström who has been my friend and workmate for over ten years now (count them!). No Simon Vincent, no Zapruda Trio – so, many thanks Simon. Thanks to my family for tolerating the interruptions that gigging and writing have caused them, not to mention Dad's horrible music leaking from his 'studio'. Formal thanks are due to the EU's i3 and Disappearing Computer Research Actions for funding to the eRENA and SHAPE projects which have supported some features of the background to this research. Thanks finally to my employer – the Centre for User-Oriented IT-Design (CID) at the Royal Institute of Technology (KTH), Stockholm, Sweden – for not really noticing how much time my 'part time' MMus has truly taken. This work is dedicated to my mother Barbara Bowers with love.

Appendix

Screenshots

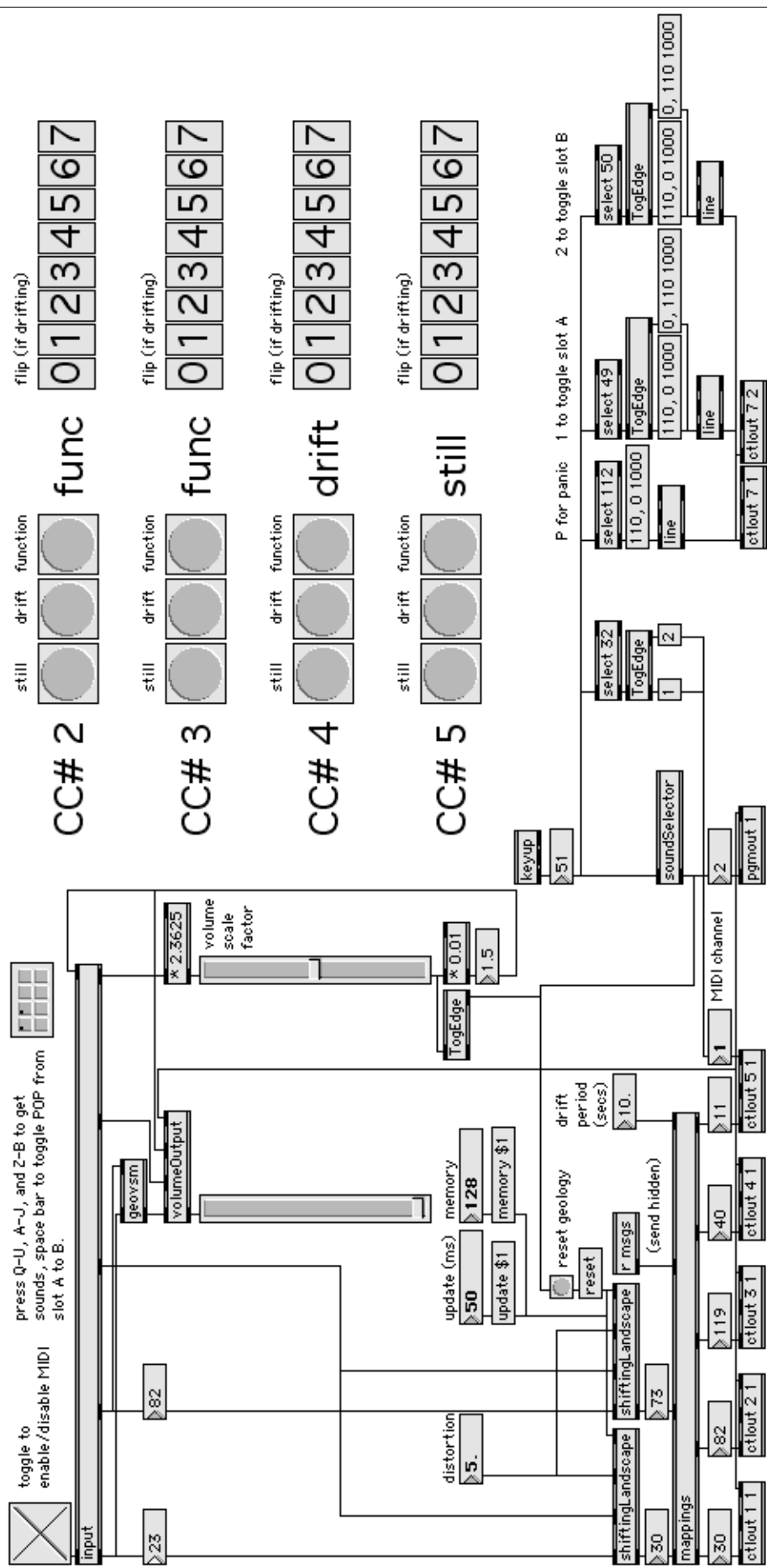


Figure 1. Geosonos

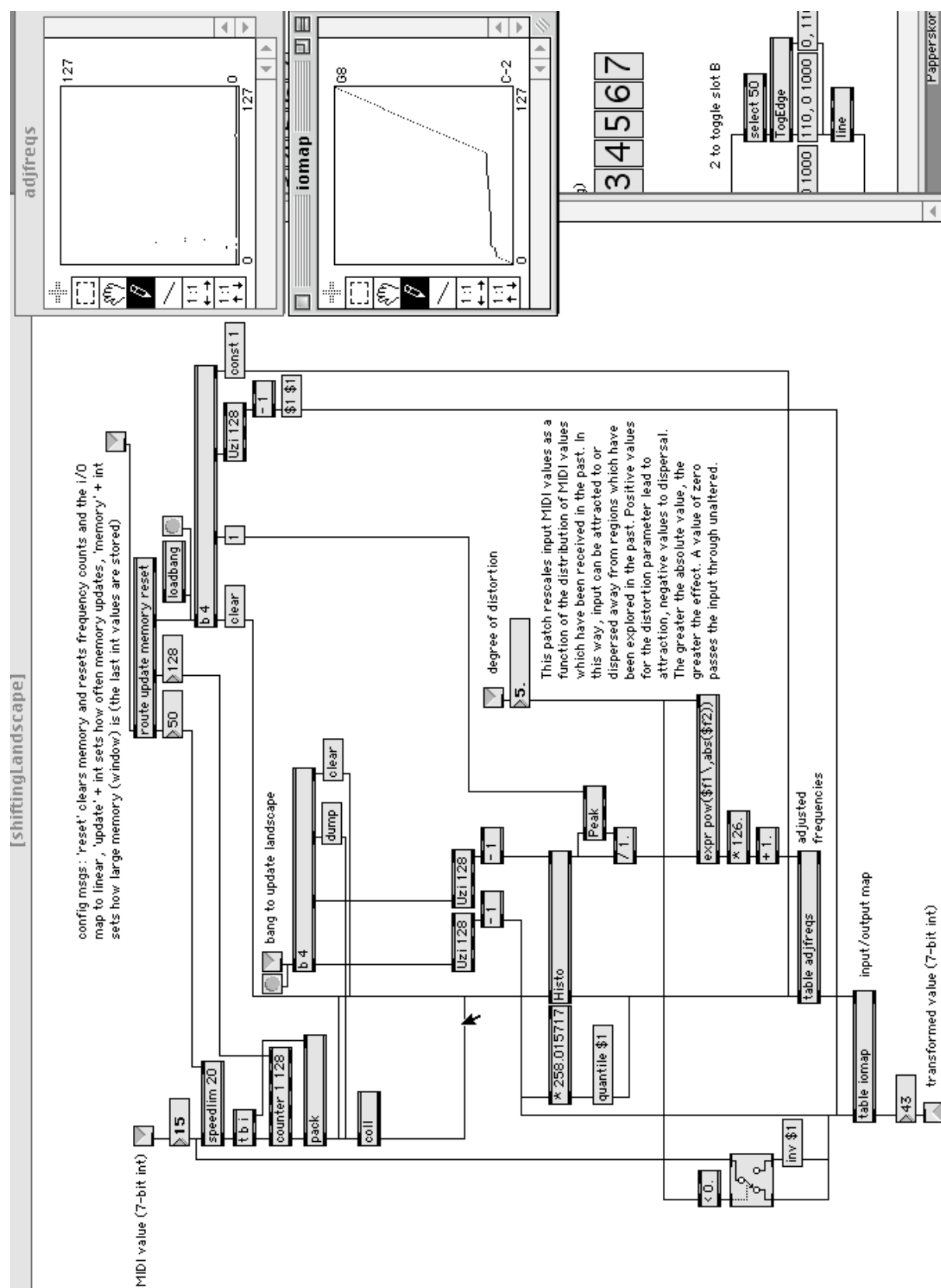


Figure 2. Shifting landscape in Geosonos

Pseudo $1/f$ noise with controlled bit flipping

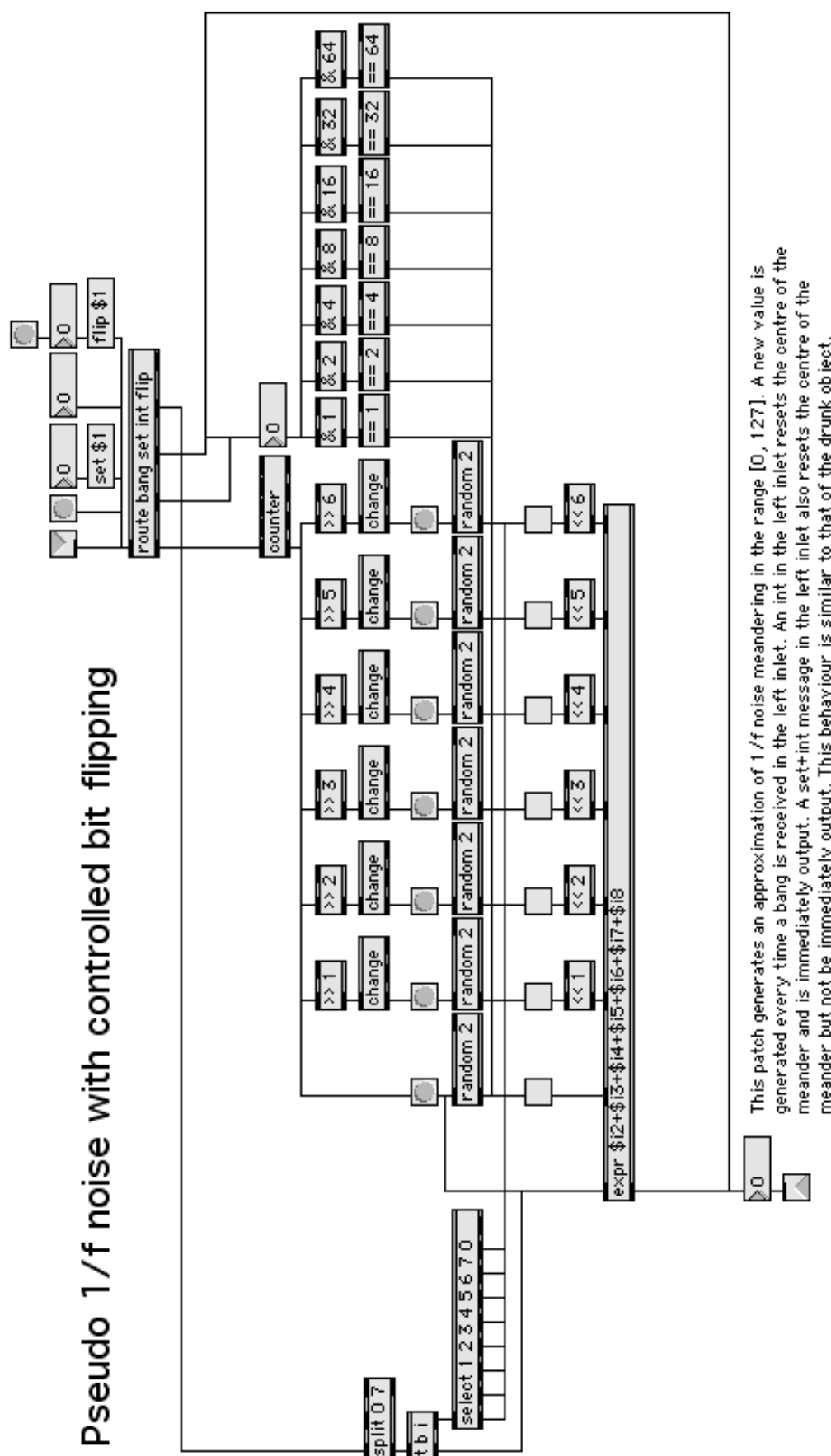


Figure 3. Algorithmic drift in Geosonos

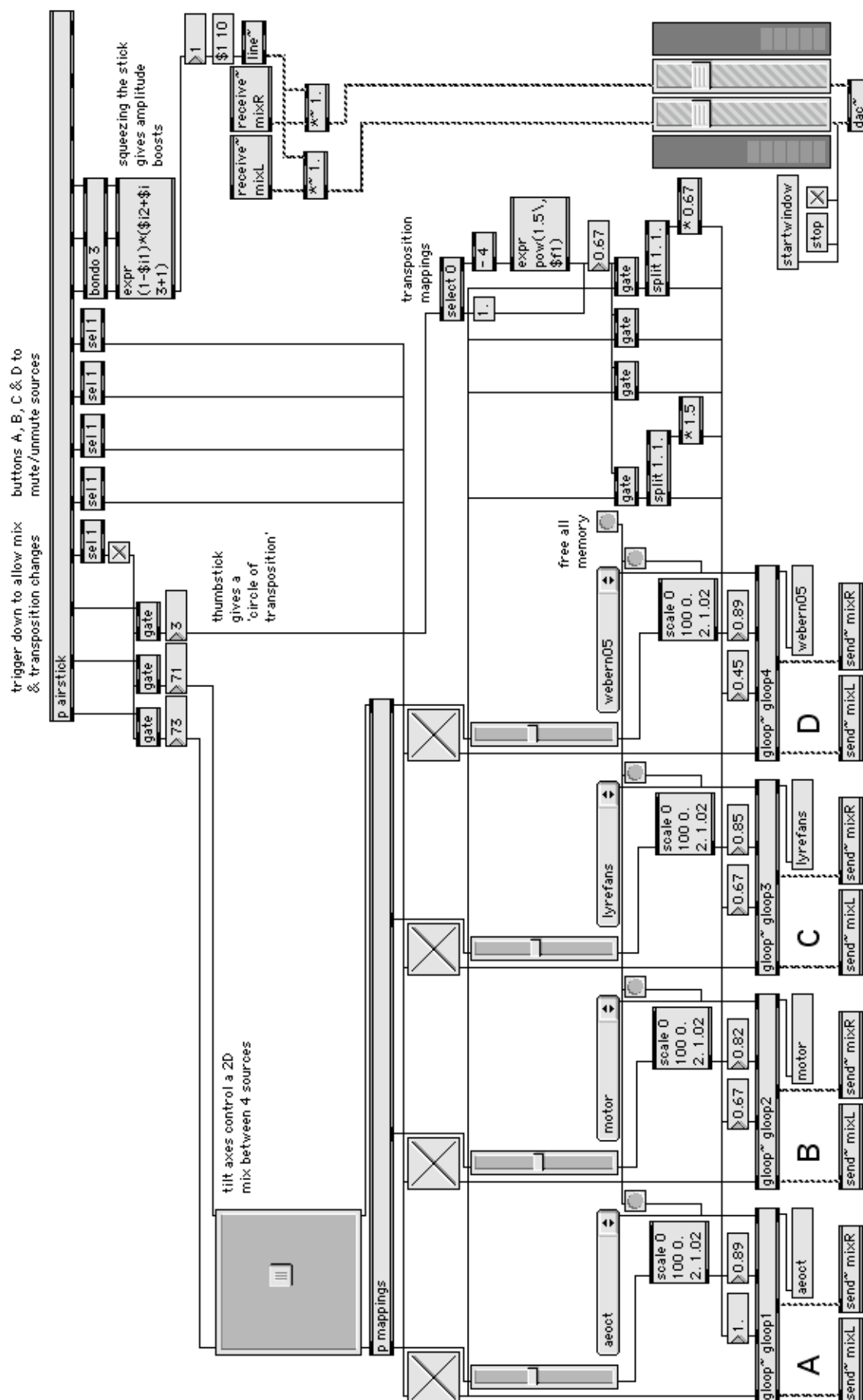


Figure 4. AirMix

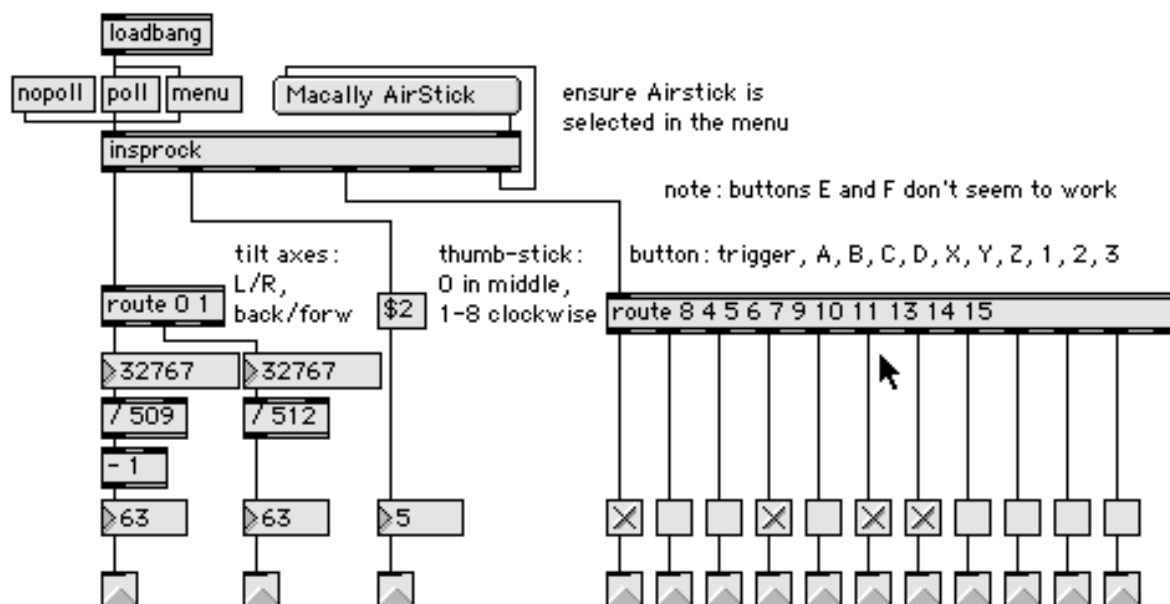


Figure 5. Interpreting the AirStick

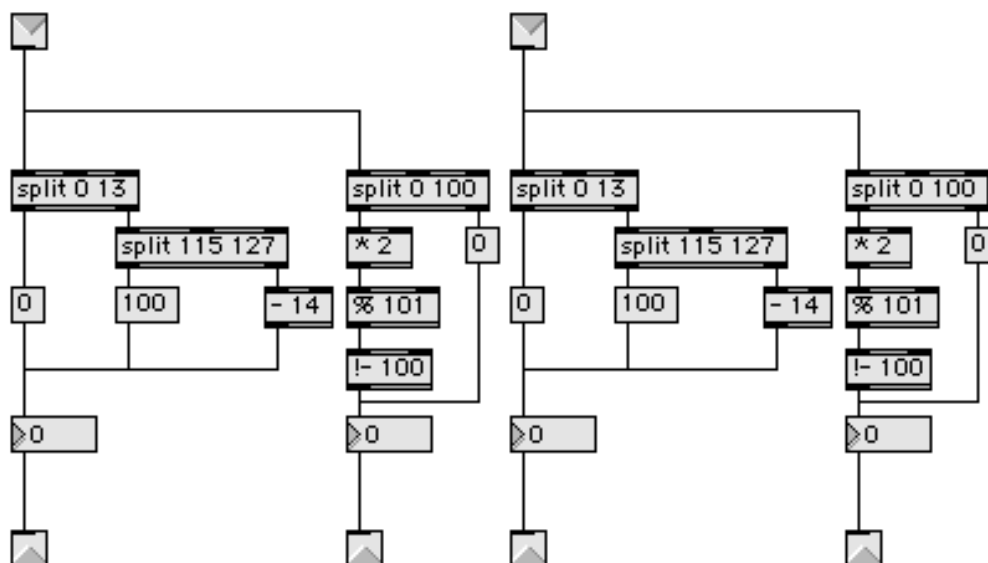


Figure 6. Calculating mix control in AirMix

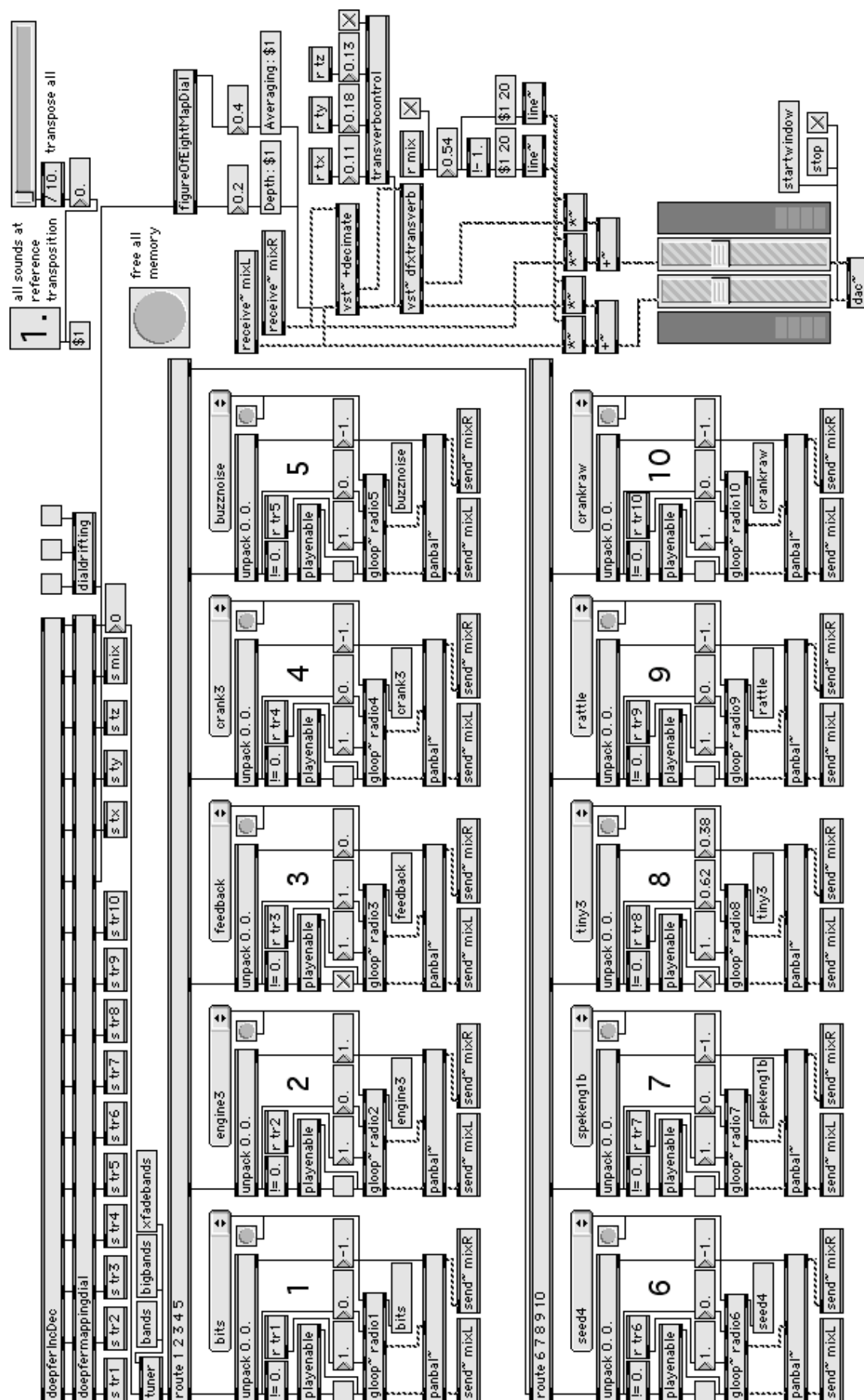


Figure 7. The Dial

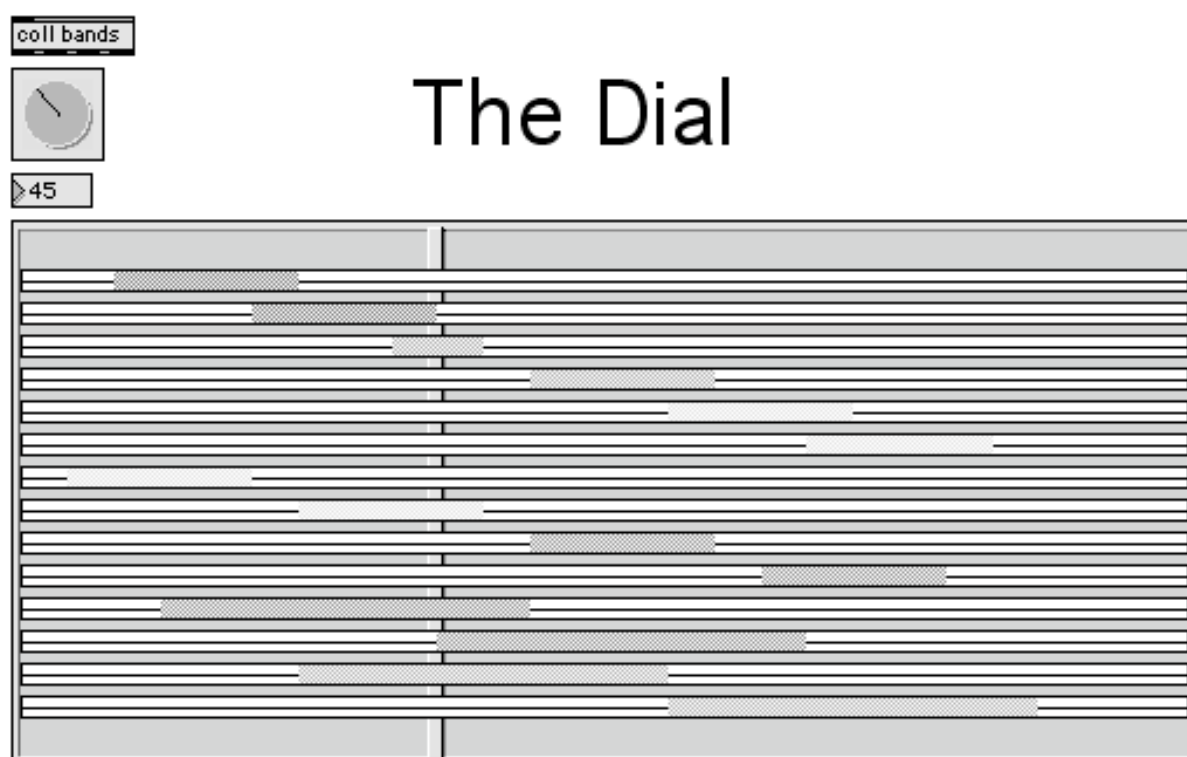


Figure 8. The tuner interface.

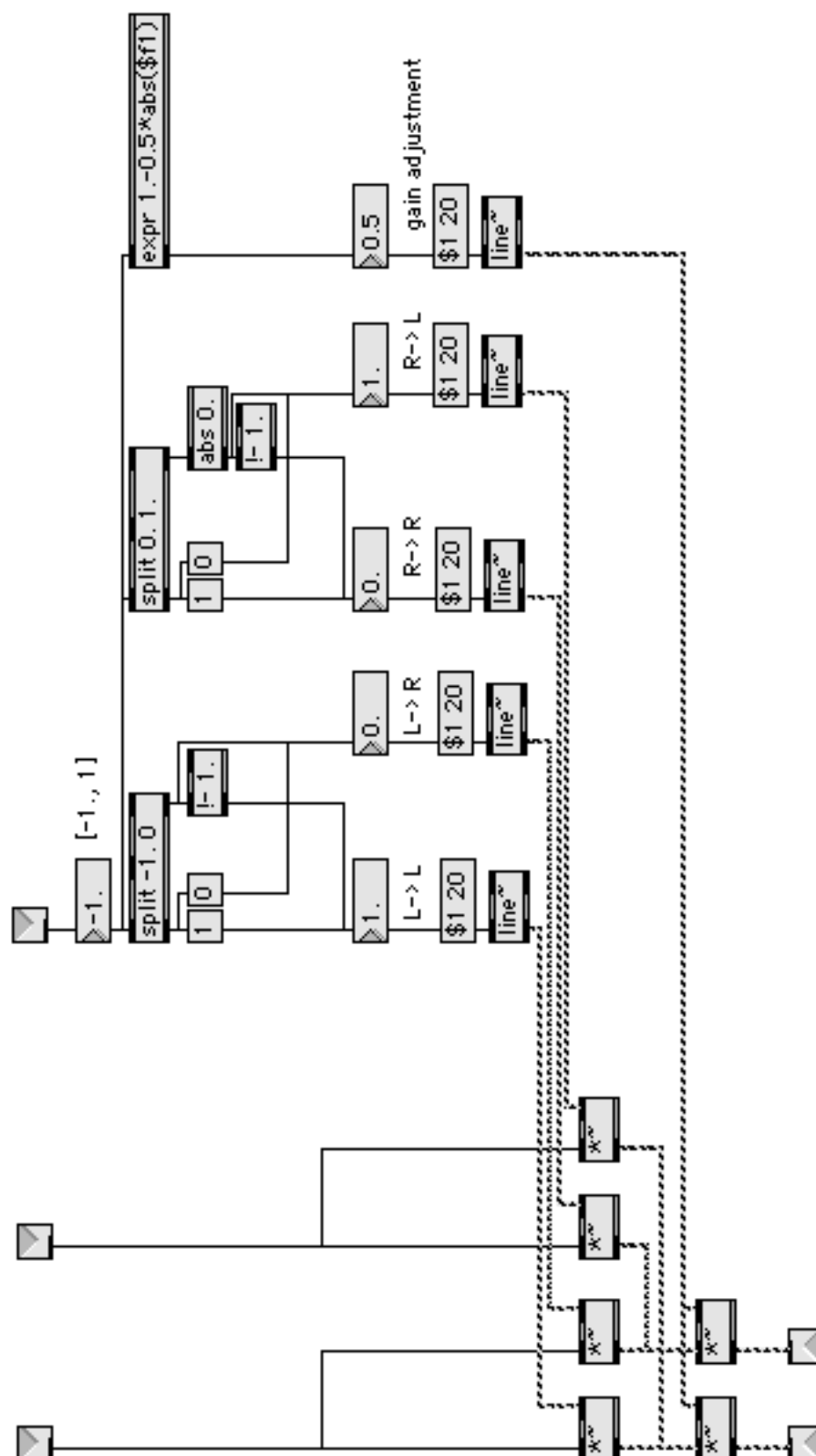


Figure 9. Spatialisation in The Dial

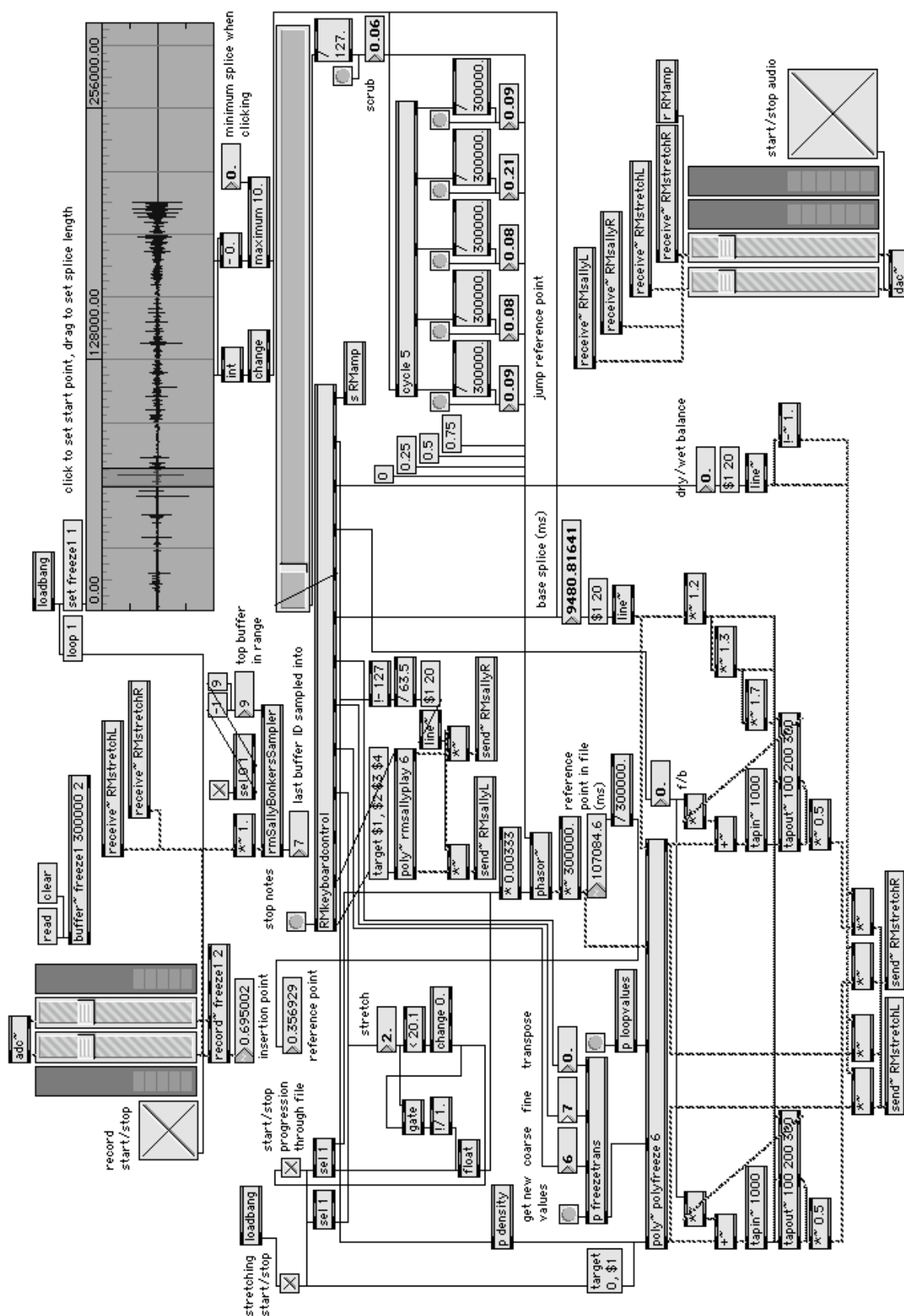


Figure 10. The Reincorporation Machine

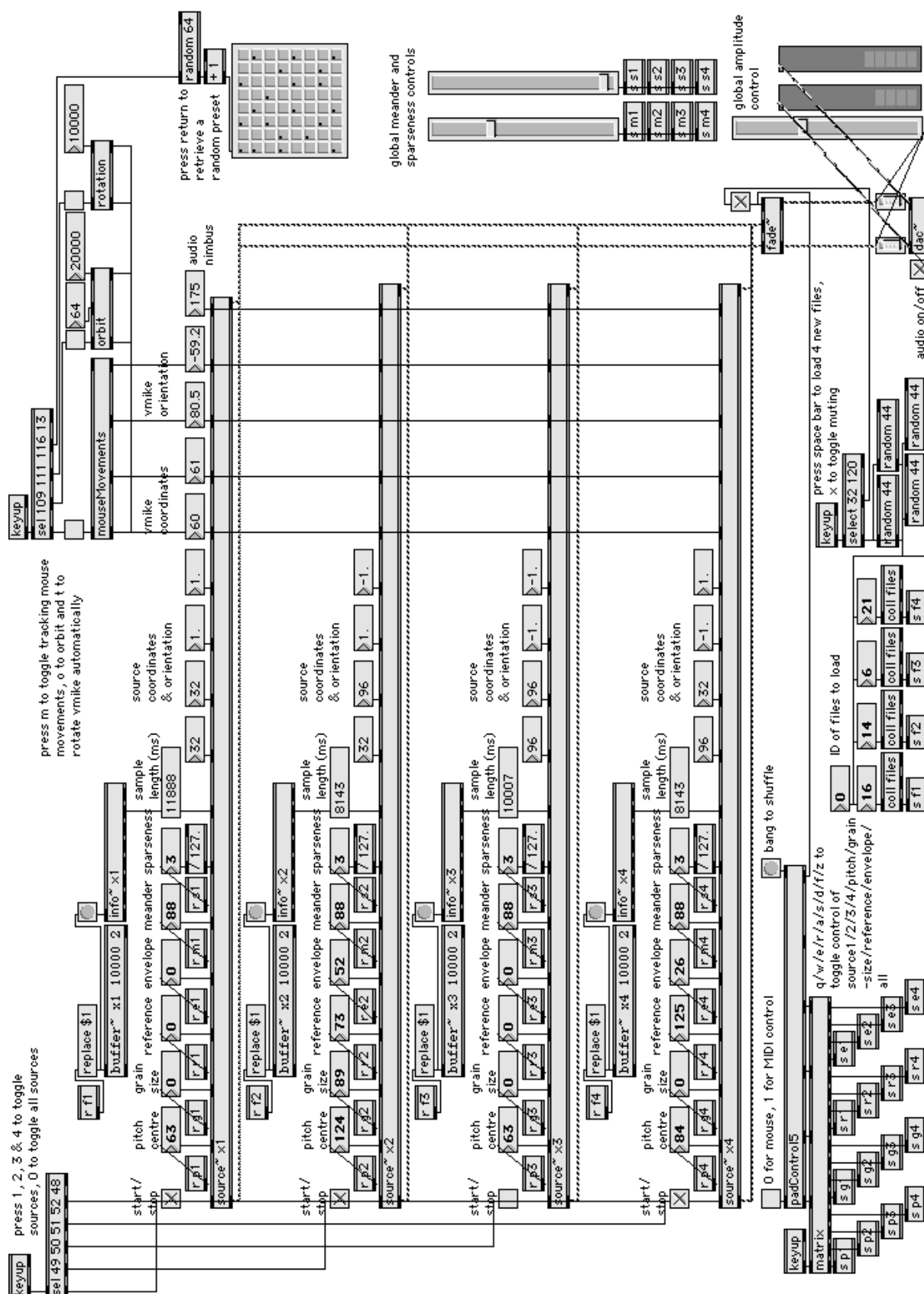


Figure 11. InCamera

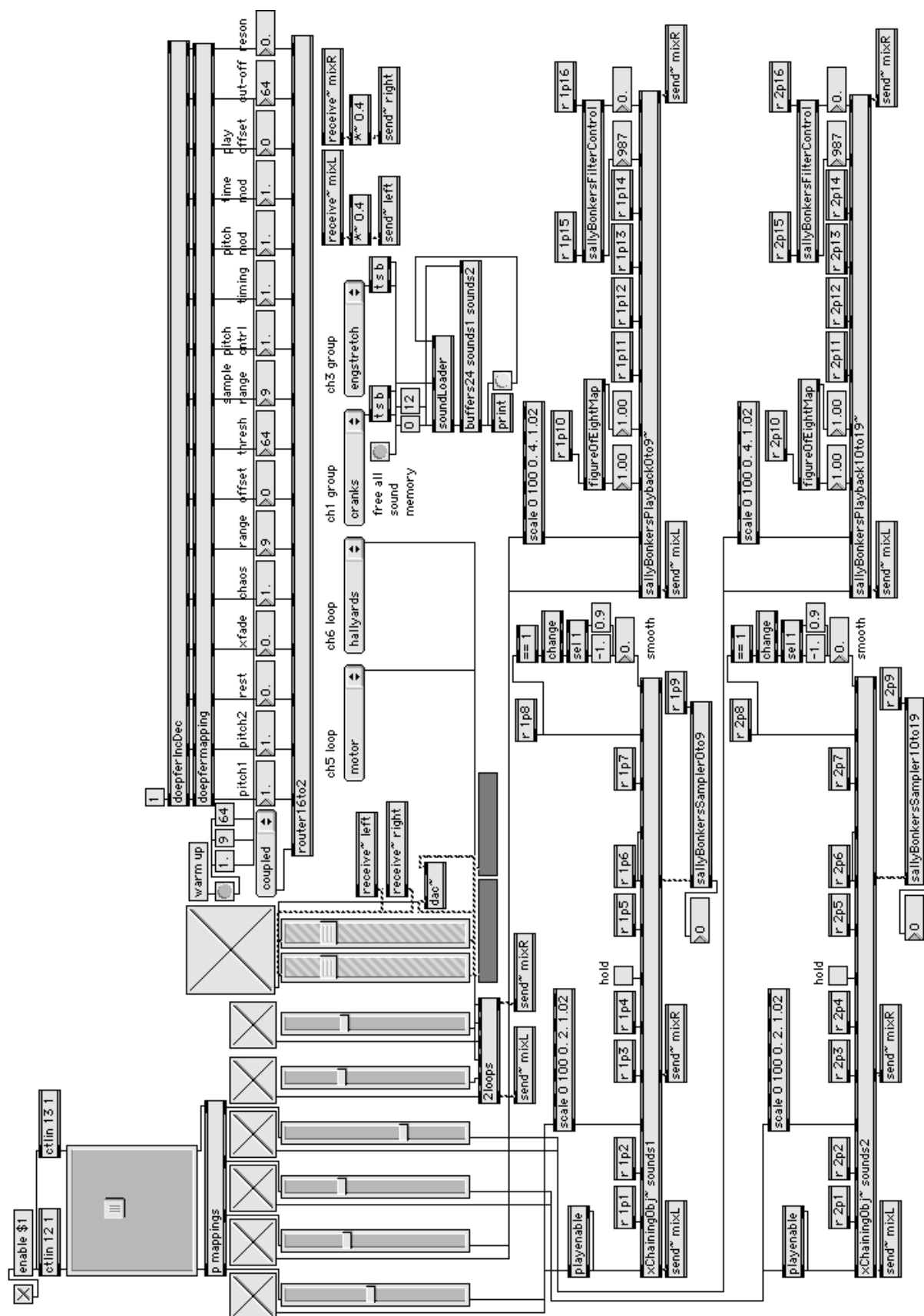


Figure 12. Lyapunov's Tonic

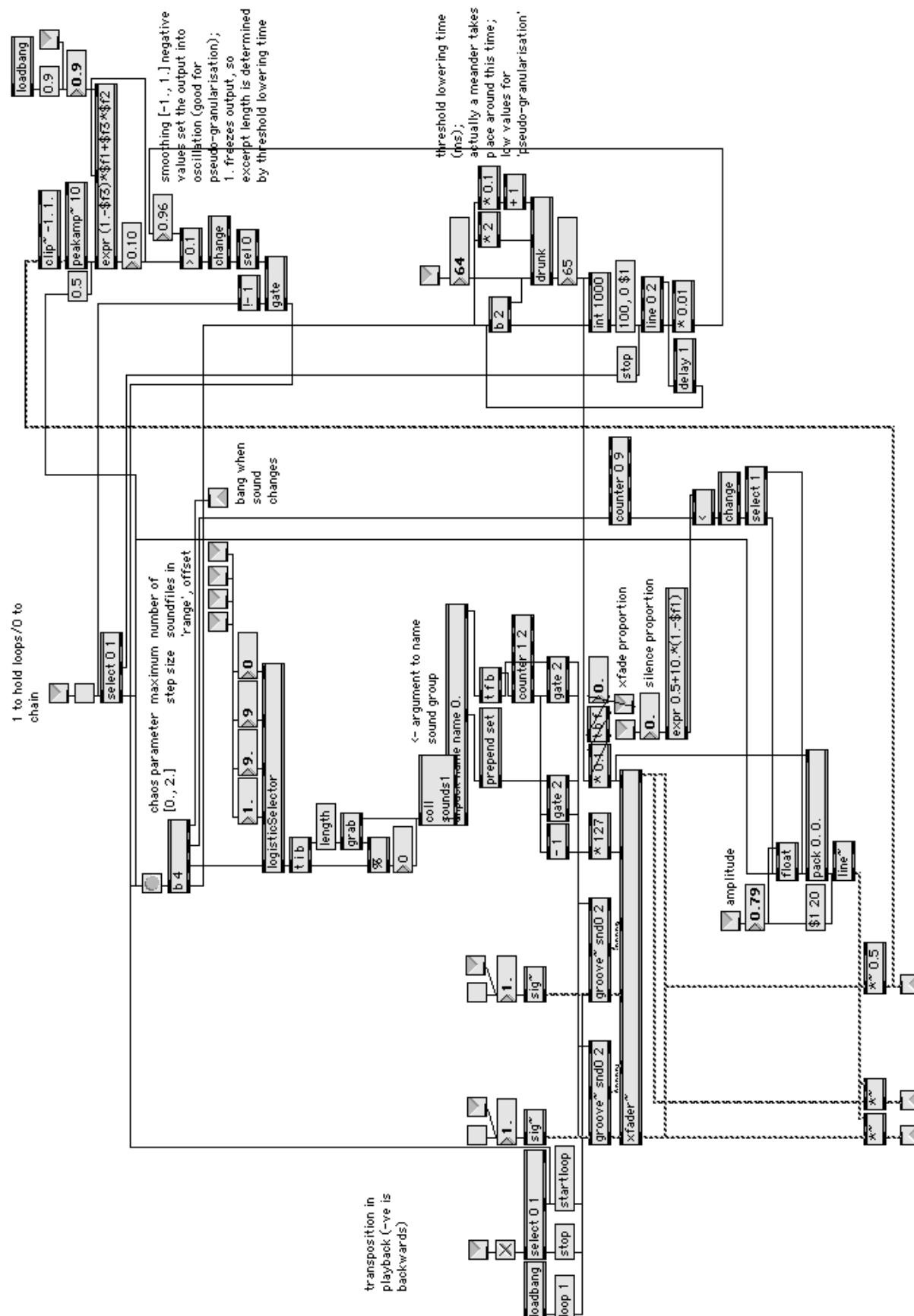


Figure 13. Inside the cross chaining object

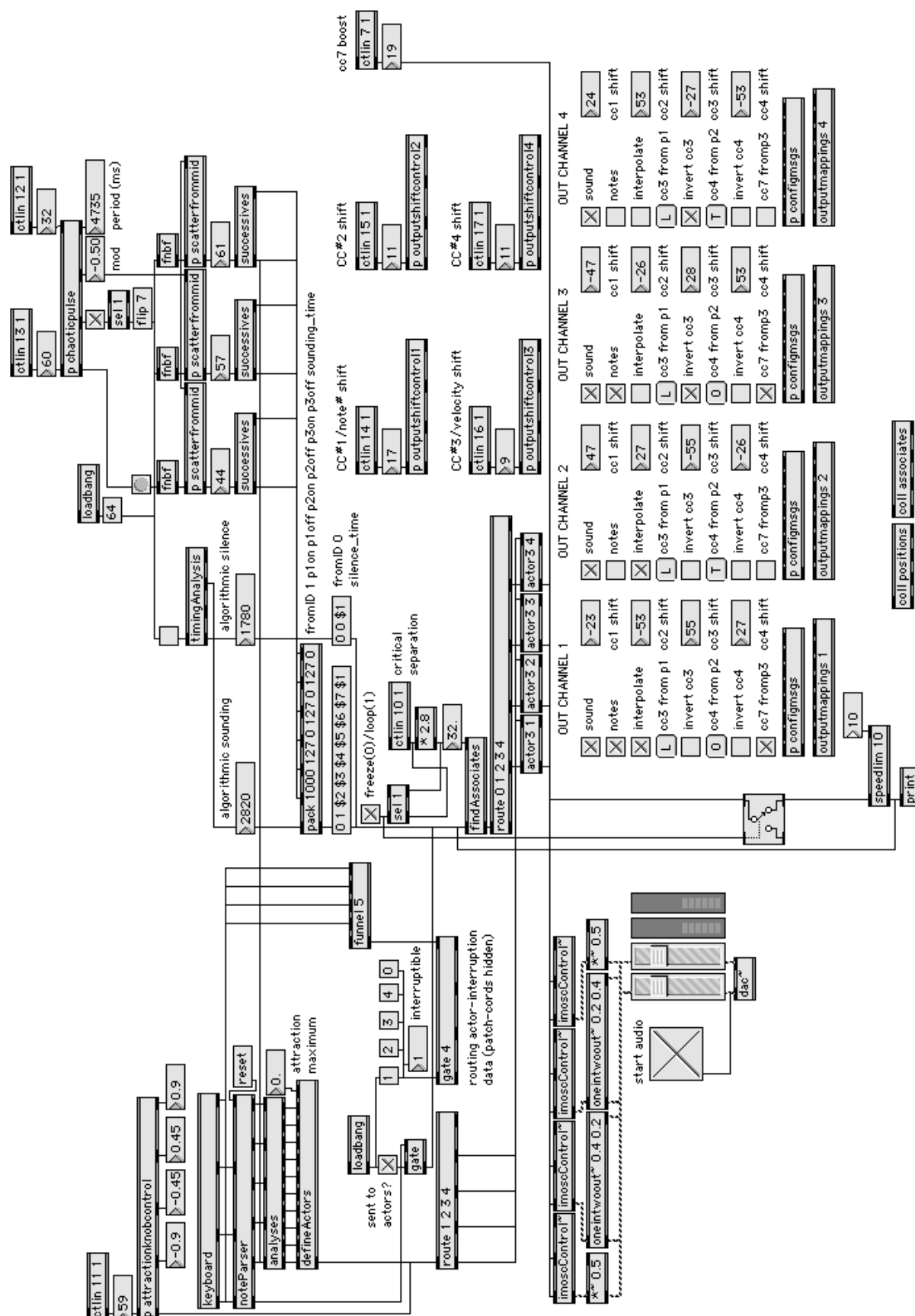


Figure 14. The Improvisation Machine

References

- Adorno, T. (1936/1989). On jazz. *Discourse*, 12 (1), 45-69.
- Anderson Sutton, R. (1998). Do Javanese gamelan musicians really improvise? In Nettl, B. and Russell, M. (eds.) *In the course of performance: Studies in the world of musical improvisation*. Chicago: Chicago University Press.
- Atkinson, J.M. and Drew, P. (1979). *Order in court: the organisation of verbal interaction in judicial settings* London: Macmillan.
- Attali, J. (1985). *Noise: the political economy of music*. Manchester: Manchester University Press.
- Bahn, C. and Trueman, D. (2001). *Interface: electronic chamber ensemble. New instruments for musical expression*. Workshop at CHI 01, Seattle.
<http://www.csl.sony.co.jp/person/poup/research/chi2000wshp/papers/bahn.pdf>
- Bailey, D. (1992). *Improvisation: Its nature and practice in music*. New York: Da Capo.
- Bakhtin, M. (1981). Discourse in the novel. In *The Dialogic Imagination* (M. Holquist, ed.). Austin: University of Texas Press.
- Balaban, M. et al. (1992). *Understanding music with AI*. Cambridge: MIT Press.
- Benjamin, W. (1927). *The work of art in the age of mechanical reproduction*.

http://pixels.filmstv.ucla.edu/gallery/web/julian_scaff/benjamin/benjamin.html

- Berliner, P. (1994). *Thinking in jazz: The infinite art of improvisation*. Chicago: Chicago University Press.
- Blacking, J. (1995). *Music, culture, and experience. Selected papers of John Blacking*. Chicago: Chicago University Press.
- Blum, S. (1998). Recognizing improvisation. In Nettl, B. and Russell, M. (eds.) *In the course of performance: Studies in the world of musical improvisation*. Chicago: Chicago University Press.
- Boon, J. and Decroly, O. (1995). Dynamical systems theory for music dynamics. *Chaos*, 3 (1), 501-508.
- Boulez, P. (1976). Quoted in Durrant (1989).
- Bowers, J. (2001). Crossing the line: a field study of inhabited television. *Behaviour and information technology*, 20 (2), 127-140.
- Bowers, J. and Hellström, S.-O. (2000). Simple interfaces for complex sound. In *CHI 2000 Supplement*. New York: ACM Press.
- Bowers, J. and Martin, D. (1999). Informing collaborative information visualisation through an ethnography of ambulance control. In *Proceedings of ECSCW 99*. Dordrecht: Kluwer.
- Bowers, J. and Rodden, T. (1993). Exploding the interface. In *Proceedings of InterCHI 93*. New York: ACM Press.
- Bradshaw, J. (1997). *Software agents*. Cambridge: MIT Press.
- Chadabe, J. (1997). *Electric sound*. New York: Prentice Hall.
- Childs, B. and Hobbs, C. (1982/1983). Forum on improvisation. *Perspectives on New Music*, 21.
- Chion, M. (1991). *L'art des sons fixés, ou la musique concrètement*. Fontaine Éditions Métamkine.
- Cubitt, S. (1998). *Digital aesthetics*. London: TCS Press.
- Davidson, M. (1997). Interview with Evan Parker.
<http://www.shed.ac.uk/misc/rec/ps/efi/fulltext/mparkin2.html>
- Dean, R (1992). *New structures in jazz and improvised music since 1960*. Milton Keynes: Open University Press.
- Durant, A. (1989). Improvisation in the political economy of music. In Norris, C. (ed.) *Music and the politics of culture*. New York: St. Martin's.

-
- Emmerson, S. (1986). The relation of language to materials. In Emmerson, S. (ed.) The language of electroacoustic music. London: Methuen.
- Emmerson, S. (2000a, ed.). Music, electronic media and culture. Aldershot: Ashgate.
- Emmerson, S. (2000b). Losing touch?: the human performer and electronics. In Emmerson, S. (ed.). Music, electronic media and culture. Aldershot: Ashgate.
- Fehrenbach, G. (2002). Twilight music: Interview with Fred Frith.
<http://www.heise.de/tp/english/inhalt/musik/12669/1.html>
- Floyd, S. Jr. (1991). Ring shout! Literary studies, historical studies, and black music inquiry. *Black Music Research Journal*, 11 (2): 265-87.
- Garfinkel, H. (1967). Studies in ethnomethodology. Englewood Cliffs: Prentice Hall.
- Gaver, W. and Martin, H. (2000). Alternatives: exploring information appliances through conceptual design proposals. Proceedings of CHI 00. New York: ACM Press.
- Goodwin, M. (1990). He-said-she-said: Talk as social organization among black children. Bloomington: University of Indiana Press.
- Haas, R. (1931). Handbuch der Musikwissenschaft. Potsdam: Athenaion.
- Hammersley, M. (1997). Reading ethnographic research: A critical guide. London: Longman.
- Heath, C., Luff, P., vom Lehn, D., Hindmarsh, J. and J. Cleverly (2002). Crafting participation: Designing ecologies, configuring experience. *Visual Communication*, 1 (1), 9-34.
- Hughes, J., King, V., Rodden, T. and Andersen, H. (1994). Moving out of the control room: ethnography in system design. In Proceedings of CSCW 94. New York: ACM Press.
- Johnstone, K. (1999). Impro for storytellers. London: Faber.
- Jost, E. (1975). Free jazz. New York: Da Capo.
- Kelly, M. (1998) Simon H. Fell. <http://www.shef.ac.uk/misc/rec/ps/efi/fulltext/ftfellav.html>
- Kochman, T. (1986). Strategic ambiguity in black speech genres: Cross-cultural inference in participant-observation research. *Text*, 6 (2), 153-170.
- Kramer, L. (1995). Classical music and postmodern knowledge. Los Angeles and Berkley: University of California Press
- Leslie, E. (2000). Walter Benjamin: overpowering conformism. London: Pluto.
- Leudar, I. and Antaki, C. (1988). Completion and dynamics in explanation seeking. In Antaki, C. (ed.) Analysing everyday explanation - A Casebook of Methods. London: Sage.

- Martin, J. (1996). Interview with Derek Bailey.
<http://www.shef.ac.uk/misc/rec/ps/efi/fulltext/mbailin2.html>
- Monson, I. (1996). *Saying something: Jazz improvisation and interaction*. Chicago: Chicago University Press.
- Moser, H. (1955). *Musik Lexikon*. Hamburg: Sikorski.
- Munthe, C. (n.d.). What is free improvisation?
<http://www.shef.ac.uk/misc/rec/ps/efi/fulltext/ftmunt.html>
- Nattiez, J.-J. (1990). *Music and discourse: Toward a semiology of music*. Princeton: Princeton University Press.
- Nettl, B. (1998). Introduction. In Nettl, B. and Russell, M. (eds.) *In the course of performance: Studies in the world of musical improvisation*. Chicago: Chicago University Press.
- Nettl, B. and Russell, M. (1998). *In the course of performance: Studies in the world of musical improvisation*. Chicago: Chicago University Press.
- Overholt, D. *The MATRIX: A novel controller for musical expression*. New instruments for musical expression. Workshop at CHI 01, Seattle.
<http://www.csl.sony.co.jp/person/poup/research/chi2000wshp/papers/overholt.pdf>
- Parker, E. (1992). *Man and machine*.
<http://www.shef.ac.uk/misc/rec/ps/efi/fulltext/demotu.html>
- Perlman, M. (1993). *Unplayed melodies: Music theory in post-colonial Java*. PhD thesis, Wesleyan University.
- Preece, J., Rogers, Y. and Sharp, H. (2002). *Interaction design*. London: Wiley.
- Pressing, J. (1984). Cognitive processes in improvisation. In Crozier, R. and Chapman, A. (eds.) *Cognitive processes in the perception of art*. Amsterdam: North Holland.
- Pressing, J. (1997). Some perspectives on performed sound and music in virtual environments. *Presence*, 6, 1-22.
- Prévost, E. (1995). *No sound is innocent*. Matching Tye: Copula.
- Pycock, J. and Bowers, J. (1996). Getting others to get it right: an ethnography of the fashion industry. In *Proceedings of CSCW 96*. New York: ACM Press.
- Racy, A (1991). Creativity and ambience: An ecstatic feedback model from Arabic music. *World Music*, 33 (3), 7-27.
- Roads, C. (1989, ed.). *The music machine*. Cambridge: MIT Press.
- Roads, C. (1996). *The computer music tutorial*. Cambridge: MIT Press.

- Roads, C. (2002). *Microsound*. Cambridge: MIT Press.
- Roads, C. and Strawn, J. (1985). *Foundations of computer music*. Cambridge: MIT Press.
- Rosenboom, D. (1995). *Improvisation and composition - synthesis and integration into the music curriculum*. Proceedings of the 71st Annual Meeting, National Association of Schools of Music, Reston, VA, USA. http://music.calarts.edu/~david/dcr_writings/dcr-NASM.html
- Rowe, H. (2001). *Machine musicianship*. Cambridge: MIT Press.
- Sacks, H. (1995). *Lectures on conversation*. Oxford: Blackwell.
- Schaeffer, P. (1966). *Traité des objets musicaux*. Paris: Editions du Seuil.
- Schoenberg, H. (1967). *Fundamentals of musical composition*. London: Faber and Faber.
- Seeger, C. (1977). *Studies in musicology 1935-1975*. Berkley and Los Angeles: University of California Press.
- Slawek, S. (1998). *Improvisation in Hindustani music*. In Nettl, B. and Russell, M. (eds.) *In the course of performance: Studies in the world of musical improvisation*. Chicago: Chicago University Press.
- Small, C. (1998). *Musicking*. Hanover: Wesleyan University Press.
- Smalley, D. (1986). *Spectro-morphology and structuring processes*. In Emmerson, S. (ed.) *The language of electroacoustic music*. London: Methuen.
- Smalley, D. (1992). *The listening imagination: listening in the electroacoustic era*. In Paynter, J. et al. (eds.) *Companion to contemporary musical thought*. London: Routledge.
- Stevens, J. (n.d.) *Search and reflect*. Photocopy.
- Suchman, L. (1987). *Plans and situated action: The problem of human machine communication*. Cambridge: Cambridge University Press.
- Sudnow, D. (1978/2002). *Ways of the hand*. Cambridge: MIT Press.
- Taylor, T. (2001). *Strange sounds: Music, technology and culture*. London: Routledge.
- Thom, B. (2001) *Machine learning techniques for real-time improvisational solo trading*. In *Proceedings of IS 2001*. Ljubljana, Slovenia.
- Ungvary, T. and Kieslinger, M. (1996). *Towards a musician's cockpit*. In *Proceedings of ICMC 1996*, Hong Kong.
- Voss, RF and Clark, J. (1978). *1/f noise in music: music from 1/f noise*. *The Journal of the Acoustic Society of America*, 63 (1), 258-263.

- Windsor, L. (2000). Through and around the acousmatic: the interpretation of electroacoustic sounds. In Emmerson, S. (ed.). *Music, electronic media and culture*. Aldershot: Ashgate.
- Winkler, T. (1998). *Composing interactive music: techniques and ideas using Max*. Cambridge: MIT Press.
- Wishart, T. (1985/1996). *On sonic art*. Amsterdam: Harwood.
- Witkin, R. (1998). *Adorno on music*. London: Routledge.
- Woolgar, S. (1988, ed.) *Knowledge and reflexivity*. London: Sage.
- Xenakis, I. (1971/1992). *Formalized music : Thought and mathematics in composition*. New York: Pendragon.