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The musical process in the age of digital intervention

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Picture taking is first of all the focusing of a temperament, only secondarily that of a machine (Susan Sontag)

This text found its first form in response to invitations from John-Richard Sageng and Geir Johnson in Oslo and Sally Porter in Oxford to present keynote papers at conferences which they were organising, and I am grateful to them all. An earlier version of the text was commissioned by the Norwegian philosophical journal Parergon, but has never appeared in public.

What follows should be understood as a practitioner's attempt to identify some recent aesthetic tendencies in the work of musicians working speculatively with technology. The paper takes as its point of departure previous publications (Waters 1997/ 2000) in which a range of broad cultural and attitudinal shifts are regarded as establishing the preconditions for 'hybrid thought', and begins to engage with the notion of a 'digital aesthetic'. It is particularly concerned to establish the extent to which currently identifiable aesthetic tendencies can be understood as responses to digital technologies, and to frame these within the broader cultural shifts - acknowledging that the technology in some way ushers in radical or innovative aesthetic possibilities without assuming the technologically determinist position adopted by some theorists of the digital age. In broad terms I am likely to suggest that responses to digital technology indicate a development and continuation of existing aesthetic concerns, tending to manifest themselves as a broader social engagement with or diffusion of those concerns, to at least the same extent that they are indicative of aesthetic innovation. This might be partly to do with the fact that the signifying practices, such as music, with which we are concerned, are best understood as primarily social rather than technical strategies and discourses.

As an electroacoustic composer the observations here are seen as continuing a process about which I have already written elsewhere:

a change in sensibility from what I characterise as an acousmatic¹ culture (broadly concerned with sounds as

¹ The concept of acousmatic culture is understood as revolving around Pierre Schaeffer's notions (Schaeffer, 1966), elaborated by Michel Chion (Chion, 1983, 1991), of *l'écoute réduite* or reduced listening, and *l'objet sonore* or the sound object.

and for themselves - as 'material', and based - in historical practice - on analogue technology) to a sampling culture (concerned with context, and based on digital technology)... ... [which] is intimately bound up with a broader shift in cultural perspective, sometimes characterised as a shift from the modern to the postmodern (2000: 56)

The question therefore is about the significance of this shift in music and the sonic arts: whether digital technology introduces new aesthetic possibilities which are identifiable as responses to that technology - rather than to the broader social changes - and whether the shift in the storage and retrieval systems for music which results from digital technology is significant enough to warrant an addition to Simon Frith's useful taxonomy of music's previous stages of development. Frith (1996: 226-7) develops the notion of a 'folk' culture - in which music is stored in the body; of an 'art' culture - in which music is stored in the text; and of a 'pop' culture - where music is stored in recordings. Framed historically, the question becomes: does the introduction of digital technology signal an aesthetic shift in music which is as fundamental as that which resulted from the intervention of recording in the late 19th century?² What's interesting is that Frith's three modes of analysis of musical storage and retrieval map very closely on to those of Attali's scheme in *Noise* (Attali, 1985), in which he writes of the political economy of music as underpinned by a logic of sacrifice, a logic of representation, and a logic of repetition. But Attali goes further, proposing a fourth category, a logic of composition, in which individuals are empowered to construct their own signifying practices - to sing their own individual songs. Is the sampler - and the culture it signals - the harbinger of a new political economy of music in which music is stored everywhere, in diffuse, virtual space, accessible as material for the performing out of individual preferences?

This perhaps optimistic prediction might be regarded as fetishising the technology and failing to acknowledge that the commodity in short supply, now as ever, is not technological possibility, but imagination. Paul Théberge, in the most thorough analysis to date of the relationship between consumers, music and technology (Théberge, 1997: 190-1) draws a comparison between Adorno's criticisms of Stravinsky for 'fetishising the means' - by 'gratuitously' demanding new sounds from orchestral instruments - and critics of sampling technology who decry the severing of 'sounds' from their context within a 'compositional logic'.

My approach is to attempt to distinguish several 'waves' of response to digital technology³ in which a 'first wave' response might be to embrace the most immediately 'seductive' or accessible

² My argument is going to be that it might, but we should be wary of the gap between theory and (social) practice. Theories of what is happening at the so-called cutting edge of a cultural change are often found wanting in describing how that change manifests or consolidates itself in more general culture. This may be, at least in part, because the theorists in question are able to operate at some remove from ordinary social activity. This is probably best indicated by the type of language they choose to use, which functions primarily to distance them from non-theorists, but therefore also disengages them from ordinary social discourse. Historically, such theorists do not have a good record in accurately identifying the ways in which a society will be affected by a new technology

³ an approach for which I'm indebted to Derrick de Kerckhove, with whom the issue was discussed by video-conference as part of the Ultima Festival, Oslo, 1998.

characteristics of the technology in a relatively ‘uncritical’ manner - what might be regarded as a ‘line-of-least-resistance’ approach to producing with digital means. In this regard the by now legendary (but quite possibly apocryphal) report that over 80% of Yamaha’s DX7 FM synthesisers returned to base for servicing in the mid 1980s had never had their presets altered in any way serves as a paradigm. Clearly, however, such superficial responses to the possibilities of digital technology (among visual artists and musicians, for example) are counterbalanced by more critical approaches, and it is these which I would characterise as ‘second wave’ responses.

Such ‘second wave’ responses may differ substantially in their objection to ‘superficial’ use of digital technology - Some regard the emergence of skills which address the ‘digital nature’ of digital information as essential, rejecting too-familiar metaphors from analogue activity; overlapping in some respects with this approach is a concern to blur or ignore differences between ‘human’ and ‘machinic’ agency in digital interventions; some continue a modernist concern with ‘difficulty’ and the resistance of materials and processes; some flag the medium of delivery or storage as equal in significance to any putative ‘content’; some simply develop strong antithetical aesthetic reactions to what they perceive as utilisations of ‘too obvious’ qualities characteristic of work produced with digital technology.

In the few examples below I attempt to uncover some of these responses in recent practice, beginning with the last tendency in the preceding list.

Noise in the system

A number of elements combine in the embracing of noise (in various forms) in recent work. Noise and distortion have long formed part of the expressive vocabulary of pop music and it is unsurprising therefore that it should be in pop music that a reaction to the smooth professional surface, which digital technology allows in both image and sound, should emerge. This concern with the signifying possibilities of noise, dirt and distortion is given an additional discursive dimension (analogous to the spatial - to left/right, or distant/present continua) in the digital world of high resolution, extended dynamic range and enhanced spectral clarity, by the introduction of a continuum of resolution from distorted to clear reproduction, from deliberately compressed or reduced dynamic or spectral range to ‘professional’ polish. As an expressive device this continuum is particularly well used by artists who emerged from the Bristol club scene in the early 1990s, notably Tricky and Portishead, and is rapidly adopted by electroacoustic music practitioners.

This continuum is articulated partly through the collision of digital ‘hi-tech’ technologies with resolutely ‘lo-tech’ solutions to musical problems. Many artists adopt ‘lo-tech’ approaches as part of an explicit political agenda - avoiding implication in ‘corporate’ music making by utilising turntables, garage electronics and cheaply available (often deliberately archaic) domestic music technology. Such issues (along with a pragmatic economic sense) inform the use of turntables as performance devices in the urban subculture of the US in the 1980s, and their use by experimental musicians (Christian Marclay, Philip Jeck⁴) intent on drawing attention to the medium of the recording. A typical

⁴Philip Jeck is best known for his *A Vinyl Requiem* (London, 1993) with Lol Sargent, a

electroacoustic work from the 1990s, Ed Kelly and Nick Melia's *Block Groove*⁵ uses shellac, vinyl and digital recordings and the interventions, treatments and 'degradations' characteristic of all three, to construct a piece in which there is play between an 'acousmatic' sensibility, the performed interventions, and intrusions from the material support of the recording which frequently emerge as 'content'. This might be interpreted as a McLuhanesque signalling of the mode of representation, of the means of encoding, as inseparable from 'what is represented'⁶.

Collaborative working practices

Within what might be termed the media arts, of which the sonic arts are a productive subset, it is possible to identify an increased tendency toward collaborative or collective working. This may emerge from the fact that, at least in the (historically) early stages of the forms of work we are considering, artists tended - often out of necessity - to work together with technicians and with programmers, as well as from the fact that the networking possibilities of the physical world are now multiplied so dramatically by networking in the digital domain. Within such collaborative enterprises, the notion of authorship is no longer a necessary condition of the work's emergence⁷, although, as media theorist Andreas Broeckmann has pointed out, "we should not underestimate the degree to which envy, fame, sex, money and power still play their roles"(Broeckmann, 1996). Some of the collaboration undoubtedly results from the degree of hybridisation between previously separate disciplines or areas of expertise which is encouraged by the increasingly similar interfaces used for manipulation of text, image, sound etc. Some I would ascribe to the physical isolation of screen-based working practices and would therefore identify as a second-wave response to that physical isolation - a critique of the inadequacy of the interface between digital devices and the user which has led to a compensatory re-socialising of the process of making. Finally, and most obviously, the connectivity which results from current networks facilitates and even encourages the likelihood that collaborative activity might result from input at geographically disparate input locations. Currently such distributed activity is most successful in situations where temporal synchronisation is not critical

performance/installation involving projection from 2 slide- projectors and 2 movie-projectors onto a bank of 180 'Dansette' record players. Work by New York-based Marclay, whose business card apparently describes him as 'record player', is documented at <http://www.artpace.org/artists/artist.jhtml?ID=90>

⁵ ARiADA, University of East Anglia, 1999

⁶ As I write, the irrepressible Madonna's latest video appears on MTV - *Don't Tell Me* (2000) foregrounds technologies of representation by featuring the singer astride a bucking bronco in an image, initially 'clear' - and read as 'real', which becomes striated by the horizontal transmission lines of NTSC encoding as we zoom towards it. In as further 'nesting' of the modes of representation we then pan out to reveal that all of the image thus far has been reproduced on a huge multiple screen in the desert, and that 'reality' as we knew all along, has even greater resolution.

⁷ The use of the term 'emergence' here can be taken as indicating a conscious utilisation of the changing boundaries between the subject (listener, interpreter) and the maker (artist, composer), in which the former interact with what the latter has made, such that the work can be said to emerge in its 'use', rather than having been designed in its entirety by the artist and then 'presented'. This too might be regarded as a principle enhanced by the mechanisms (technological and social) associated with digital technologies.

- non time-based work or ‘ambient’ musical activity, and although technically surmountable, the problems associated with dispersed real-time synchronised activity make it most evident in contexts where there is significant institutional support.

As an example of such practice, some of the work of Köln-based group Knowbotic Research⁸ might serve. Their 1996 project *Anonymous Muttering*⁹ utilised granulation - a process in which streams of audio data are broken down into multiplicities of small packets of samples, the behaviour of which is controllable in real time (with respect to many parameters, from the read speed of the input data, through the length and pitch of the samples, to their looping, overlapping, etc) - the best analogy is probably that of the swarming and streaming behaviours of insects or bird flocks. Knowbotic took sound material from various dispersed DJ events which were granulated in real time, and which various individual users in different public locations, or via the internet, manipulated and transformed simultaneously with a series of different interfaces. The result could be experienced in the various urban spaces involved, and via the internet (using RealAudio¹⁰), but the interventions of any one of the individual collaborators could not be distinguished, nor was a distinction made between human and computer agency. Andreas Broeckmann identifies this lack of distinction between “interventions by apparatuses and human agency” as crucial to an exploration of “the machinic principles of aesthetic production”(Broeckmann, 1996)¹¹. In a later paper the same author draws a useful distinction between forms of agency in networked environments:

Whereas the collective is ideally determined by an intentional and empathetic relation between agents within an assemblage, the connective rests on any kind of machinic relation and is therefore more versatile, more open, and based on the heterogeneity of its components or members. (Broeckmann, 1998)

Within the sometimes slow-to-adjust world of academic electroacoustic music there are nevertheless several important shifts which indicate that collaborative and collective working practices are becoming more prevalent. The first is that the economic and logistical demands which are made of humanities departments in the UK necessitate increased numbers of students working with unchanged or reduced facilities, and academics and studio directors are forced to devise dynamic strategies for turning this to educational advantage. Changes in the technology itself - the fact that it simply works faster - and its ubiquity due to reducing cost, compensate to some extent for reduced institutional resourcing. More importantly, the informal networks which develop from home or student ownership of sophisticated technologies, and the real-time possibilities which emerged most noticeably with the most recent generations of desktop computers and real-time software (e.g. Apple Macintosh G3 and G4 computers running software such as Max/MSP¹² or SuperCollider¹³) tend to lead to ‘ensemble’ working practices: Granular synthesis, for example, with its emphasis on real-time interaction with sound material, can provide a powerful argument for collaborative enterprise, as it may often involve a live

⁸ Homepage at <http://io.khm.de/>

⁹ documented at http://www.khm.de/people/krcf/AM_rotterdam/

¹⁰ <http://www.realaudio.com/>

¹¹ to which I am also indebted for much of my information on Knowbotic Research.

¹² <http://www.cycling74.com/>

¹³ [http:// www.audiosynth.com/](http://www.audiosynth.com/)

(conventional) performer working with one or more composer/performers who, in tandem with the software, may radically intervene in the performed object.

Products such as LiveJam - a networked real-time 'jamming' software for the PC - compound such tendencies among computer-equipped musicians generally, being free to download, and undemanding of the technology (minimum hardware requirements are a 486 DX 2/66 with 8 Mb RAM, Windows 95/98/NT and a TCP/IP connection, MIDI-driven input and output devices, 28.8 Baud Modem, and direct connection to the Internet (no proxy server)). The ethos of the software is evident from the LiveJam website:

LiveJam is a product that enables musicians the world over to play music or "jam" with each other LIVE over the Internet. Musicians can log in with any nickname of their choice, take a look at the rooms available, join the room of their choice (or create one of their own) and then literally make music together with other musicians (Livejam, 2000).

It is worth noting here the particular problems of music and sound-related arts in 'real-time' activity, whether these involve collaborative/network based practices or simply real-time interaction. The inherent latency in computers (time lag between input and output) can be extremely problematic in situations where the aesthetic value of the output may be extremely dependent upon momentary adjustments on the part of the performer(s) in response to the computer's interventions. The perceived responsiveness (or otherwise) of the system may be determined (in the audio domain) by differences of a few milliseconds. Such difficulties are compounded by the absence of the subtleties of multi-sense real-time communicative coding (gesture, eye-contact) which typically take place between interacting musicians in conventional acoustic performance. Even in speech my experience of real-time teleconferencing has always been of the discomfiting sensation of an exchange frustrated by time-delays in sound and image which rob the dialogue of any subtlety or suppleness, and I have often found myself referring to my co-speakers in remote locations as being 'on the video'

Renewed concern with narrative

Simultaneously with the widespread availability of digital tools in the early-mid 1980s, many signifying practices -visual arts, contemporary dance, electroacoustic music - which had for some time been characterised by self-reflexive 'abstract' work began to show a more explicit interest in various forms of narrative. The extent to which this synchronicity is causal is extremely unclear. Certainly there are characteristics of digital systems - the ubiquity of storage; the non-linear nature of digital data and the possibility for 'instant recall'; 'automatic' systems for searching, (mis)translating and categorising/organising material; the overload or saturation which result from rapid data flow - to which our attention is drawn because of similarities and differences in our use of pre-digital systems, and which perhaps suggest the need to re-evaluate what is aesthetically desirable in practice. When every aspect of one's work, at every stage of its development, can be stored and recalled, the previously crucial filtering systems of loss and forgetting disappear, to be replaced by hardware failures or consciously constructed 'loss systems'. This radically alters the texture of interaction with material. Decisions can be endlessly put into abeyance. Both of these can have an effect on the types

of formal strategy we are likely to invoke, and certainly the possibility of reviewing or revisiting every point of one's trajectory towards a particular work is contiguous with disclosing the narrative of its making. From an acknowledgement that a work can explicitly document its own making it is a relatively small step to incorporating anecdotal, or programmatic-illustrative elements, and, encouraged by the sampler's propensity for quotation and cross-referencing between works, histories, cultures and genres, it is easy to see that narratives, particularly of the fractured or non-linear variety, may emerge as a fruitful speculative playground.

Clearly the references to narrative here function in music at levels beyond the programmatic-illustrative mode with which we are familiar from much nineteenth century composition. In order to clarify the different possible relations to narrative which might be invoked in the case of electroacoustic music it may be useful to establish a crude heuristic taxonomy of 'narratives' in order to avoid confusion:

Narrative 1 (involving literal, semantically significant text)

Narrative 2 (programmatic-illustrative)

Narrative 3 (documentary-anecdotal)

Narrative 4 (documentation of compositional process)

Narrative 5 (use of structural or semantic strategies from natural language, or which are more frequently associated with the linguistic realm)

I'm not concerned here with narrative 1, nor particularly with 2, although distantly metaphoric and very generalised notions of 'landscape' or of 'creating other worlds' occur in a broad selection of discussions of electroacoustic work. Narrative 3 is more interesting in this context in its use of the presence of gathered acoustic events or environments to stand for themselves. Frequently the nature of this documentary or anecdotal material is transformed by other contextualising elements, or itself functions to recontextualise other (often non-documentary) elements. Luc Ferrari's *Presque Rien* series of works serve well as an illustration of this tendency elevated to the point of structuring principle. From this principle, and the less interventionist 'acoustic ecology' of R.Murray Schafer (Schafer, 1977) and others, has grown a 'Soundscape' movement with hugely varied aesthetic (and political) positions¹⁴. My own misgivings about the relation of such documentary anecdotalism to concepts of 'realism' and 'naturalism', is that composers operating under the guise of such concepts frequently seem to me to be insufficiently explicit about the artifice, the very unnaturalness, of the processes in which they are engaged. And of course realism and naturalism are concepts which are constantly remoulded by context. As a very young composer I remember being impressed by Stockhausen's retort to a radio interviewer's suggestion that involving electronics in music was somehow 'unnatural' with something along the lines of naturalness being determined by how something was used, rather than by its origins. Realism and naturalism seem theatrical or poetic cul-de-sacs in the sense that, if one accepts such concepts at face value, then the nature of the events or

¹⁴ e.g. World Soundscape Project-<http://www.sfu.ca/~truax/wsp.html> ; EarthEar Soundscape Info Center - <http://www.earthear.com/sscape/> ; World Forum for Acoustic Ecology archive - <http://interact.uoregon.edu/MediaLit/FC/WFAESCN/menu.html> ; The UK Soundscape Community - <http://www.mailbase.ac.uk/lists/soundscapeuk/welcome.html>

objects represented is always in some sense inadequate in terms of the experience of the physical original. Within electroacoustic music, non-interventionist documentary recording, however carefully made, can never represent objects or events in the same manner their physical presence, and this seems to point toward conscious recontextualisation or some sort of transformation or 'enhancement' as a solution to the dilemma of operating within such a narrative context. And if one's notions of the real have been tempered by, for example, familiarity with the vastly increased spectral and dynamic range associated with some electroacoustic sound in comparison with the constraints of physical acoustic systems, it becomes difficult to accept that aesthetic activity should concern itself only with the physically possible.

All electroacoustic music which uses recordable media is in some sense a documentation of the processes which went into its making, although of course this documenting need not necessarily be chronological. Narrative 4 (which is therefore an unavoidable by-product of working with any recording technology) acquires an additional significance in digital systems, where the capacity to recall any state of a work's development - to rewind and replay the temporal sequence of aesthetic decisions - allows free play in the relationship between the work's 'narrative continuity' and the narrative of its making. Narrative 4 may incorporate narrative 3 insofar as documentary recording may be one element of the broader history of a piece's construction. This is evident in electroacoustic work in which the composer is a 'metanarrational' presence in the material, gathering sound and simultaneously explicit within it. Michel Redolfi's *Desert Tracks*, Philippe LeGoff's *Meta incognita*, and many current Canadian compositions illustrate this tendency well, incorporating microphone handling noise and footsteps which, as Katharine Norman has pointed out, serve to draw attention to "the composer's performing presence" (Norman, 1994: 106). Norman's article is one of remarkably few attempts to construct a narratology of electroacoustic composition, although it does not attempt to distinguish between different modes of engagement with narrative, concentrating on the composer's performative role as 'storyteller', and proposing analogies with oral tradition. Norman's sense of 'storytelling' is usefully unrestricted to the literal (senses 1 and 2 above), and touches on aspects of narrative which coincide with all of the types above. She also draws attention to the extent to which the overlap between narratives 3 and 4 functions to allow the composer to 'own' the material, to incorporate aspects of the personal which give the work authority, and which may in turn function to allow the listeners' 'creative incorporation of the... ..experience as their own'(1994: 107).

Underlying the interrogation of the function of memory, which concludes Norman's paper, is the notion that, irrespective of the nature of the material, certain abstract structuring strategies are likely to be common to time-based human experience. This territory, involving relatively neutral concepts from natural language such as repetition and accumulation, and those more intimately associated with the (literary) poetic such as assonance, alliteration, homophony, hiatus and anagram, I have termed narrative 5. Incorporated within this category would be metaphors of 'modes of address' which might more conventionally be associated with the theatre (see e.g. Elam, 1980), including notions of rhetorical, dialogic and choral (or ambiguous) material. Among established electroacoustic composers Francis Dhomont is one of the more assiduous explorers of linguistic models, his *Syntagmes* providing an early example of the conscious utilisation of sonic elements to reproduce phonemic functions, these being modelled on the articulatory patterns of natural language (Gu erin, 1991).

Katharine Norman's most recent work proposes a 'new kind of literature' (Norman, 2000: 217) which celebrates and playfully explores the relationship between purely sonic narrative and literary narrative through a series of recontextualising 'nestings' of material which model the shifting modes of interpretation common to our experience of complex musical or literary forms.

Some of the most convincing arguments for the reuse of material, and for its incorporation into new contexts, come directly from literature. There is considerable consensus among literary theorists that an appreciation of 'intertextuality' - the mechanism by which texts can be regarded as affording meaning in relation to other texts, and in which a degree of textual interdependence (and the potential for multiple readings) is therefore acknowledged - forms an important aspect of contemporary critical practice. The genre of 'historical metafiction' is identified by Linda Hutcheon (Hutcheon, 1988) as symptomatic of late twentieth-century literary concerns, and the tendency within this genre to place documented historical material within the context of a late-modern mindset and language, or to deal with contemporary concerns within the frame of a historical language, mirrors closely some of the compositional and musical practices associated with sampling. The genre juxtaposition and overlay which preoccupies composers like Tom Wallace¹⁵ (and which Wallace attributes to the experience of urban living, in which 'environmental' sounds and those of multiplicities of musical sources constantly compete and interpenetrate) is second nature to DJs and remix producers. Although the availability of samplers obviously contributes to the likelihood of such juxtapositions occurring, equally aesthetically significant is the extent to which much live remixing activity makes use of older, analogue technologies such as the turntable, and to which aspects of genre collision or dislocation occur in purely live musical activity, whether this be the 'polystylism' of some 1980s concert music, or the impressive high-speed montages of John Zorn's band 'Naked City'.

Kevin McNeilly is one of several commentators who draw attention to the filmic nature of Zorn's work, remarking that in its 'uses of blocks of sound and rapid-fire shifts from texture to texture, section to section' it 'demands a similar attentiveness' to film. (McNeilly, 1995) As Zorn puts it:

It's made of separate moments that I compose completely regardless of the next, and then I pull them, cull them together. It's put together in a style that causes questions to be asked rather than answered. It's not the kind of music you can just put on and then have a party. It demands your attention. You sit down and listen to it or you don't even put it on. (Strickland, 1991: 128)

In a similar vein, Sten-Olof Hellström's *Sequel*¹⁶ utilises a rapid montage technique modelled on recent tendencies in youth documentary and travel programmes, in which elements are juxtaposed in such a manner that, while remaining identifiable at lower speeds, they saturate or overload the perceptual mechanism when the speed of intercutting increases.

As the interfaces for editing and constructing sound and moving images become ever more similar, such tendencies increase, driven by a common language of control and manipulation: pause, fast-forward, cut, fade, morph. But it is not at the merely technical level that the filmic connection is

¹⁵ in works such as *City Systems* (1997-99) Paradigm Discs, London - tomw@clara.net

¹⁶ Sten-Olof Hellström: *Sequel* (composer's home studio, 1995)

important. Recent film theory has argued for a reversal of the commonplace logic that reality lies in the filmic image and is supported by the sound. Within this upturned logic, 'reality' is regarded as located in the sound, the paradigm being that of the ventiloquist's dummy which is animated by the sonic domain (Altman, 1980; 1992). Although sound in isolation from image clearly functions somewhat differently, this nevertheless provides a powerful argument for a more thorough investigation of the potential of the sonic arts to carry more explicit narrative. A work by John Drever, *Cloud of Forgetting*, moves towards this position, by making use of a spoken text, initially untreated, but which becomes increasingly so, leading into a transcendental (and text-free) central section which apparently continues the (religious) narrative logic set up by the text¹⁷. As electroacoustic composers become less uneasy with various forms of narrative, and as enabling technologies become increasingly available to those who do not have to throw off modernist misgivings with the story, the tale, the chronicle or the account, the 'sonic art' field is likely to broaden to incorporate spoken, sonic and visual narrative, much in the manner of early and sporadic more recent attempts at 'radio art'.

One of the most consistently provocative composers working with explicit narrative content is the San Francisco-based Bob Ostertag, whose *Sooner or Later*¹⁸ reworks the weeping and monologue of a young Salvadorean child as he buries the father he has just seen killed. Quite apart from the immediacy and poignancy of emotional impact at the level of utterance, the documentary voyeurism and implicit political comment add a complexity and double-edgedness which are simply irresolvable through neutral acousmatic listening, and the subsequent manipulations of the material provoke important questions about intrusion, ownership, 'expressivity' and privacy. Ostertag's recent work¹⁹ has drawn on the NATO bombing of Yugoslavia, utilising 'live performance, digital sampling, and video imagery of computer games, US military training programmes, actual footage of bombing in the Balkans, and images from American television' (Ostertag, 2000) controlled from a laptop and a flight simulator joystick, emphasising that his purpose is 'to open new windows for reflection' rather than to pass judgement.

Time: Speed -The 'rate of information' problem

As with the above Ostertag example, an alternative strategy for electroacoustic music embracing narrative at the sonic level is to link the music's structures explicitly to film or video images in what could conceivably develop into an art-form parallel to that of the pop music-video. Unfortunately, much work in this area is characterised by a richness and experimentation in one of the contributory media which is in marked contrast to the banal conventionality of the other²⁰. A refreshing exception to this is the work of Neal Farwell and architect/filmmaker Simon Withers, their *The Violence of Architecture*²¹ being a sophisticated and well-integrated investigation of a gamut of possibilities

¹⁷ John Drever: *Cloud of Forgetting* (University of East Anglia, 1995-6)

¹⁸ Bob Ostertag: *Sooner or Later* (Zurich, RecRec Music, 1991) Available as CD RecDec37.

¹⁹ Bob Ostertag *Yugoslavia Suite* (*War Games* and *Two Hands*) - information from an e-mailed press release (Ostertag, 2000)

²⁰ As noted by Steven Travis Pope in an editorial for *Computer Music Journal* (Pope, 1991)

²¹ *The Violence of Architecture* was commissioned by Sonic Arts Network as part of the 'Sonic Screen' tour

from the documentary to the abstract.

Many of the aesthetic issues which emerge from the collision between sound and image can be fruitfully transferred to the domain of electroacoustic music. Film director Robert Redford, in a Channel 4 TV interview, talked of the importance of avoiding 'filling-in' the time domain with too many events, and thereby overloading the viewer/listener. One response to overloading is to shut off, to stop making sense of an experience. Paradoxically therefore, reducing the amount of input information may allow space for greater interpretative freedom on the part of the listener. The films of Andrei Tarkovsky²² are an object lesson in the creation of multi-layered richness from sparsely paced incident, and draw attention to the mechanism by which a reduction in input information may lead the information which is presented to be regarded as of greater significance. Tarkovsky's use of sound is particularly intriguing, 'at times surpassing the visual in its ability to convey certain types of meaning' (Truppin, 1992: 235). Many commentators have noticed that in combined or hybridised art-form activities, the rate of significant information in each 'channel' often has to be reduced. Henry Sayre (1989: 147) draws attention to the need in the 'multimedia presentations' (music/visuals/film) of Laurie Anderson, and in some of the works of John Cage, for what he dubs 'polyattentiveness'. In contexts where image, music and word are so intertwined, the audience's powers of interpretation, of generating meaning from comparison with previous experience, of intertextual construction, are stretched to the limit. Laurie Anderson deals with this by making the material in each of the three media rather familiar. Any unfamiliarity then comes about because of the 'interference' between the three media. In Anderson's case this is enhanced by her use of technology to distance the performer from the audience. Reliance on relatively familiar material and conventions has underpinned multi-media forms such as opera and ballet. More recent developments in contemporary dance, music-film and music-theatre may have proved difficult for audiences precisely because of the level of innovation and simultaneity evident in the different aspects of their making and presentation. Establishing strategies for aesthetically successful combinations and hybridisations of arts practices is a fundamental challenge of current aesthetic research.

Two speakers at an Amsterdam conference mark out different responses to the notion of information overload, implying strongly different aesthetic priorities. Although the first refers expressly to literature, its sense of a practice subject to rapid change in a digital age is easily transposed to a concern with the sonic:

Splash and thrill are the standards of the modern pace of life. And I maintain that this speed-culture can't be reflected in books. The modern environment of texts changes incessantly. It is as omnipresent as the electric light. The message of electric light is the pure information of its radiation. That applies to mass communication, too: *The true message of a piece of news is the inhuman velocity of its transmission*. I would like to make one point very clear: The flood of information does not imply knowledge. Mass communication does not provide orientation. *The deluge of sense does not make sense*. On the contrary: the exposure to stimuli of information overload is strongest and most fascinating if the recipient is not able to make use of it. (Bolz, 1994: 1)

of June 1995.

²² e.g. *Stalker* (1979), *Nostalgia* (1983), *Sacrifice* (1986)

Information has become a real pain. We are saturated with it. It is not the thing that is scarce any longer. The two scarce commodities are attention and trust ... [In future] our problem will not be the availability of information, it will be how do we choose to allocate our attention, that's the scarce resource. We only have 16-18 hours a day in which to do anything and allocating our attention is hard. The basis for allocating our attention in my view will be trust, and by trust I don't mean as to whether or not information is accurate, I mean as to whether or not information is relevant or worthwhile or interesting. (Liddle, 1994: 4)

Liddle continues by advancing a compelling argument for the importance of sound in the establishment of 'attention' and 'trust':

Audio always gets first claim on our attention. It's very difficult to ignore something you hear. We can selectively tune something out — the well-known 'cocktail party effect', by which we can listen to one conversation in the presence of many other ones. It's very hard for us to change the attention that we give to audio. We should be doing something about that rather than fighting it. (1994: 5)

This uniquely demanding quality of sound, the omnipresence implicit in Attali's attribution of such significance to the sonic domain, requires further investigation. Liddle suggests that in future the status of audio as an attention-demanding medium will be more widely acknowledged, and that 'future software and marketing will both realise this more explicitly'. (: 5)

Time: Non-linearity and irregularity

A further identifiable 'second-wave' response, to some degree in contention with the renewed interest in narrative, is a predilection for non-linear event patterning - an avoidance of the more obvious rhetorical devices associated equally with nineteenth-century music and much spectromorphologically-conceived electroacoustic music; an avoidance of too evident 'causalities', or of strict regularities or repetitions. Such concerns may result from the increasingly eclectic backgrounds of some of the musicians currently working with technology - John Bowers and Tom Wallace, for example, have a long history of involvement with improvised musics in which some of the aesthetic avoidances noted are also characteristic. Equally they may result simply from a reaction against the ubiquity of loops in much digital activity - loops are, after all, simple to invoke and computationally cheap. In my own work 'continuous' or 'repetitive' sounds are rarely looped, the rationale for this being that sound is 'imbued with time' (Emmerson, 1994: 98) - that is, it has intrinsic gestural 'expressivity' which is relatively unpredictable (and uncontrollable) compared with the regularities of looping or synthesis-by-rule. The microfluctuations and deviations from the grid of exact repetition are seen as essential components - or perhaps even the defining feature - of the 'musicality' of the work. Further to this - and again for aesthetic reasons relating to a conviction that irregularity, deviation and ambiguity are important contributors to significance and meaning (or at least to attentiveness and memorability) - sequencing has been conspicuously absent from my work over the past twenty years. On those rare occasions where it is used (as in the opening of *Inside/out*²³) it is in a disguised manner such that the pattern repetitions and regular structures which frequently characterise sequencer use are avoided. Its

²³ Simon Waters: *Inside/out* (University of East Anglia, 1989-90) commissioned by ORF (Vienna) for *entrée/sortie* multimedia project/broadcast.

purpose here is to record an improvisational gesture stream (from keyboard input) which then provides a single, predictably (in the sense of repeatably) irregular event sequence against which other gestures can be precisely aligned. This might be manually accomplished - with an element of improvised performance adding tension to the composing process, or more mechanistically contrived, by, for example, using the amplitude envelope of the sequenced sound as a key to trigger a gate which opens on one or several other continuous streams of audio material, thus reinforcing the amplitude peaks of the sequenced material with bursts of additional, often timbrally-related sound.

A critical and speculative attitude to the relationship between 'clock' time and 'gesture' time is well illustrated in the ongoing projects of Matt Heckert. Heckert, a one-time director of Survival Research Laboratories²⁴, has been working as a performance and sound artist since 1978. In 1988 he began working on the Mechanical Sound Orchestra - a group of computer-controlled mechanical sound instruments. This collection of industrial-scale machinery²⁵ has been presented in various manifestations in the USA and Europe, *Munich Samba* being awarded the Golden Nica for Computer Music at the 1997 Ars Electronica Festival in Linz, Austria. The juxtaposition of the temporal quantising and 'precision' of MIDI data with the inertias and unpredictabilities of physically massive machines is described thus in the Ars Electronica programme for the same year:

Continuous controllers are used to vary motor speeds and note events are used for switching transistors, and it is this information that is recorded by the software. Once recorded and stored as a sequence or sub-sequence, any series of control commands can be used at any time. When called up from the computer keyboard, controller information is sent out instantly and the system responds much like any MIDI controlled electronic instrument, but the big differences are the inertial delay encountered when stirring a machine out of rest... (Ars Electronica, 1997: 13)

Frustrations with the limitations of the 'grid' conception (regular metre and temperament) which informed MIDI's original specification have tested the ingenuity of musicians almost since its inception. The response of commercial software manufacturers has been to provide 'humanizing' functions for sequencing software which introduce 'random' deviations to the time-domain quantisation of events. As Théberge comments: "What is interesting here is how the "human" has been defined, primarily within technical culture, as "random"..." (Théberge, 1997: 226) The inadequacy of this solution to replacing 'machinic precision' with 'gestural precision' is countered only by the ingenuity with which some musicians are able to 'trick' such software or hardware into producing acceptable results.

Time: Transformation

The concept of 'transformation' preoccupies numerous practitioner-theorists over the past two decades, occupying a key position in the writing of Trevor Wishart, where, with 'gesture' and 'space', it is regarded as a key concern for a composer operating in a musical world conceived in terms of continua rather than grids or 'lattices'. (Wishart, 1996) Denis Smalley has also contributed an influential essay

²⁴ <http://www.srl.org/>

²⁵ http://www.matheckert.com/MSO/Sound_Machines.html

on the topic (Smalley, 1993) and it is no surprise that artists whose primary concern is sonic should regard a term which reflects the prioritising of time, rather than space, as so significant. In a broader sense the 'transformational' can be seen to underpin contemporary concerns with constructing and shifting identities and realities - much discussed by those in digitally-based arts practice. On a more pragmatic level, a 'time-base' is frequently identified by those artists who eschew conventional categorisation as the essential factor in their work and is obviously crucial to any analysis of common ground in increasingly interdisciplinary arts practice.

The importance of transformation arises from the characteristic that, irrespective of the category of the experience, the precise nature of any change or movement from 'event A' to 'event B' may be perceived as of greater significance than the nature of the events themselves. Frequently notions of skill or professional ability seem to be bound up with this phenomenon. Theatre directors and choreographers who have 'set' certain moments (tableaux, steps) frequently ask performers to 'find a way of getting from' A to B which follows an internal (or physical) logic. In musical performance the precise character and control of movement between notes may be a primary determining factor in the perceived expertise of the player. In television soap operas the much-vaunted 'naturalness' of the dialogue in British productions (in comparison with US or Australian output) turns on the carefully observed nature of the interactions, hesitations, overlaps and transitions between lines.

Of course crucial distinctions exist between the manner in which we perceive transformation (in the sense of shift in identity) in the visual and sonic domains. Whereas a 'morph' (morphological transformation) between two visual events can be read instantaneously at any point in the transformation, sonic events require time to become established and identifiable, and transformations between 'events' are not perceptually linear, tending to proceed discontinuously through phases of ambiguity and lurches of recognition - qualities which have frequently frustrated over-simple attempts to mirror techniques between visual and sonic domains.

At a purely sonic level, as a technique of sound manipulation granular synthesis²⁶ occupies an interesting position, allowing the suppleness of temporal control and event distribution previously associated with sound-generating synthesis systems but with the spectral and cultural richness of sampled input. As such systems become both intuitively and accurately controllable they introduce the possibility that even 'fixed' electroacoustic musics might be reinterpreted (remixed) through subtle redistribution of events and time relationships in real-time. Previous techniques which have allowed transformation in the sound domain (such as convolution - in which the frequency spectrum of one sound is mapped onto the frequency and amplitude profile of another) have, until recently, proven somewhat unpredictable to control and unconvincing in resolution. Recently, however, such algorithms have become considerably more sophisticated to the point where they are accurate enough to impose the reverberation characteristics of specific spaces onto sound material in an uncannily convincing manner.(Robjohns: 1999) From such pseudo-naturalistic applications it is likely that more radical but equally convincing aesthetic possibilities will rapidly emerge.

²⁶ see e.g.: <http://www.sfu.ca/~truax/gran.html>

In practice, electroacoustic music seems to mirror technological possibility in a rather predictable manner, exhibiting formally episodic, block-like characteristics in the analogue domain, where it was subject to the exigencies of cut-and-splice assembly, and becoming more characteristically transformational -in the sense of exhibiting gradual or continuous shifts in nature or with greater formal ambiguities - when digital technology makes such 'smoothness' possible. To some extent it is unsurprising that what is technically feasible transmutes into what is aesthetically desirable, particularly where the criteria of 'successful' composition have for some time equated, as Mike Vaughan points out, with the notion that 'processes of construction associated with the studio environment [should] remain hidden in performance'.(Vaughan, 1994: 116)

As I have indicated before, however:

Increasingly... .. composers have been prepared to challenge this aesthetic norm. Those who do so with a critical agenda tend to express the need to react against the smooth surface which it is now so easy to produce in any medium using digital technology. In the digital composition studio the urge to polish and clarify - to smooth out - is very strong, as a result of which certain types of filtered resonance have now become as much of a 'cliché'²⁷ as obviously reversed sounds, or as loops with glitches in them used to be. The work of Tom Wallace, for example, marks a deliberate refusal of this aesthetic position, this being most evident in abrupt cuts to silence and in fades which draw attention to themselves by their use of unusual or uneven envelopes²⁸. While clearly a composer with plenty of conventional technical skill, Wallace reacts against the 'smooth surface', which he sees as falsely indicative of such skill, and therefore associated with spurious notions of professionalism. (Waters, 2000: 67)

But perhaps the crucial aspect of transformation's prominence in digital arts activity is the arrival of hardware and software capable of real-time activity and intervention in human input, at a cost within the reach of individuals who are not affiliated to institutions. This aspect will be addressed at greater length under 'Interactivity' below.

Time: Storage & Instant Recall

As I have written elsewhere, the sampler elegantly utilises two of the fundamental characteristics of digital systems: massive non-linear data storage and the capacity to address that stored data at any point instantly. In doing so it effectively (and by design) blurs the distinction between 'creative' and 'disseminative' technologies:

Technologies of mass dissemination have begun to blur in function with technologies of conventional instrumentality. Sampling can be regarded, then, as representing an important step in the re-empowerment of 'listeners' as composers, both in the sense that the new configurations of familiar sounds encourage 'listening again', and in the more profound sense that sampling blurs the distinction between technologies of production and reproduction, and therefore between composer and listener. (Waters, 2000: 76)

²⁷ Of course the notion of cliché is itself indicative of the prevalence of the notion of avoidance of traces of technical construction, and of the inadequately thought-through relation between electroacoustic 'tradition' (such as it is) and innovation.

²⁸ Tom Wallace: *andRain* (University of East Anglia, 1994)

Of course, such observations apply to some extent to the CD or minidisc player - now frequently used as performance tools, in addition to functioning as high quality sources of sampled 'material'. As noted above, the potential for storage and recall also leads to a fascination with archiving, evident in the visual domain in the work of, for example, Christian Boltanski, but more generally in the emergence of 'digital museums' such as that associated with the Ars Electronica Center in Linz²⁹. There is a delicious irony in the extent to which the fluidity and transience of some aspects of digital culture (websites and their addresses, for example - especially illegal download sites - or online multi-site performances) are counterbalanced by immense social and economic pressures to fixity and permanence. Perhaps - in a more critical exploration of the play between these two counterbalancing tendencies - a digital equivalent of the sort of filter system which operated to limit the survival of pre-digital aesthetic production (the cost of publishing and printing books, for example) will emerge as a factor in systems for storage and diffusion.

Such issues impinge on aesthetic production not least because a significant factor in the process of aesthetic development is the existence of (one's own) previous work. Beyond the obvious notion of perfectibility - that in each work at some level one hopes to supplant and improve upon the perceived inadequacies of the previous attempt - there is the more mundane fact that each work generates a large proportion of unused material at various stages of development. Within my own work this backlog of unresolved compositional problems has always been reinvested in the subsequent project to some degree, with two inevitable consequences: The first is that the 'status' of material becomes extraordinarily fluid - what might have been a relatively complete musical 'statement' can reappear as a sample source for improvisatory inclusion in another work - distinctions between 'source material', 'transformations', and 'completed sections' are contingent only on a particular instance of use. The second is that a degree of continuity is established (at least for the maker) between works which usefully blurs the sometimes arbitrary disjunction of the completion of 'the work' from the ongoing process of 'working'.

Interactivity

The term 'interactive' tends to be framed differently in the worlds of 'electronic arts' and music, and as those two fields increasingly overlap it might be useful to unpick some of the differences. Whereas in electronic arts the term tends to privilege aspects relating to 'individually-determined navigation' through an experience, or to the contingency of input from the non-human participant in the interaction, the musical field has recently concentrated far more on qualitative issues around the subtlety and suppleness of the interface, and of the immediacy of the system's response. The relative urgency of the 'real-time' response issue can be judged from the fact that a recent research project (Rogala, 2000) on interactive art quotes response times of greater than 100ms as adequate for 'real-time' activity, while musical applications frequently encounter 10ms 'latencies' as problematic in creating transparent response to physical input.

As a 'second wave' response to the problem of constructing genuinely interactive aesthetic tools, such

²⁹ <http://www.aec.at/>

demands grow from the long history of intimate familiarity with an extraordinarily rich and malleable set of interactive interfaces for sound production: conventional acoustic instruments. Recognising the possibilities of, for example, physical modelling synthesis systems (Eckel et al 1995; Smith, 1996) in which some attributes of Newtonian physics can be ignored, or where the physical characteristics of sets of materials can transform over time, players and composers look for interfaces to such systems which can utilise the propensity for play - for speculative or improvisational strategy characteristic of acoustic instruments. Such 'improvisation' strategies frequently share a sense of utilising the exhilarating immediacy and subtlety of control, and simultaneous capacity for 'out-of-controlness', which is characteristic of physical feedback systems. Much current compositional activity results from attempts to subvert the tendency of the digitally-based studio to replace such direct physical feedback systems with controls which are mapped to replicate such systems, but which are insufficiently complex and immediate in their response. As skills in analysing physical feedback systems and in mapping develop, digital control systems are likely to prove indistinguishable from³⁰, and ultimately more flexible than, their analogue counterparts.

One fruitful approach is to extend the capacities of existing acoustic instruments. Jonathan Impett's 'metatrumpet' (Impett, 1994) involves a series of sensors³¹ attached to a concert instrument, running through an I-Cube interface³² to a Macintosh Powerbook equipped with Max/MSP and a custom-developed suite of programmes. These allow for real-time composition in which every aspect of the work emerges as a result of the interaction between live performance and meticulously designed, complex but familiar Max/MSP patches. The strengths of Impett's project grow out of his exploration of a particular and personal set of skills and interests over a considerable timespan. Paradoxically, while there was no intention to develop anything other than a personal tool, what can be learned from this particular instance of interface-building has a value which outweighs more idealistic attempts to produce 'generic' solutions. What the project illustrates with clarity is that aesthetic value is bound up with specific instances of mapping - that as digital tools are open ended mapping (and remapping) machines, there is no longer any significance in the fact that one particular set of inputs can be used to control or intervene in a set of outputs. What is significant is the nature of the controls and interventions - their appropriateness to the physicality of the input, and the legibility of the relationship between such input and the system's interventions and outputs in social space. This distinction would for me define the difference between a 'first' and 'second wave' response to interactivity. Unfortunately the majority of projects claiming interactivity are either naive celebrations of the banal possibility of mapping, or unsophisticated switching devices in which the level of interactivity is of the same order as that of the fruit machine.

Xavier Berenguer, referring to earlier research (Garzotto et al, 1995), lists some of the more established guiding principles for the successful design of interactive systems, noting:

³⁰ Where this is the aim. Of course the remapping possibilities of digital systems may in the long term render replication of analogue functions an irrelevance.

³¹ Mercury switches, pressure, ultrasound, Hall-effect, acceleration and breath sensors are used, and pitch to MIDI devices and envelope followers also operate on the acoustic signal.

³² <http://www.infusionsystems.com/>

...in the first place the programme's "richness", that is to say abundant information elements and paths to access them. In the second place, the "ease" of use, or the accessibility of information and the simplicity of the operations which lead to it. "Consistency" is also desirable, the programme's regularity, the similar management of similar elements. The user must be able to guess meaning and purpose from any element of the programme, its "self-evidence". Finally, Garzotto notes another evaluation criterion of an interactive's design: its "predictability", the capacity it gives the user to anticipate operation results. (Berenguer, 1997)

Of course, as soon as such principles are articulated they invite critique, and the 'ease of use' principle in particular can be identified as problematic in several respects. This principle informs the design of much 'interactive educational' software, on the mistaken basis that the short-term attractiveness this produces constitutes real interest. More pertinently for the current discussion, aesthetic production and (modernist) notions of value are tied up in the social domain, and for many practitioners, with notions of difficulty - of the 'resistance' of materials, or working 'at the limits of' the capacities of tools and instruments. The fluctuations and behavioural unpredictabilities of analogue systems under extreme conditions have a recurring position in aesthetic activity, Edward Said's useful characterisation of performance as 'an extreme occasion' (Said, 1991: 1) and John Coltrane's obsessive exploration of the unstable sonic 'breaks' of the saxophone providing just two examples. Digital systems 'under stress', however, behave differently, tending to cut out rather than oscillate into the distortions and transformations which have come to connote 'expressivity'.

Few have attempted to deal with this in a critical manner. Shigeto Wada, a current ARiADA research student, regards such concerns as evading the issue of the particularities of digital systems. Rejecting the notion of modelling analogue systems in the digital domain, he proposes³³ that we allow digital systems to produce a 'characteristically' digital sound - fuelled by integer streams rather than digitisations of analogue input - which we need to learn new strategies to control and understand. In a similar vein he proposes the development of 'non elegant' programming such that the breaks and reconnections of complex systems are embraced as part of the aesthetics of digital operation.

Less contentious, but similarly critical of established principles of interactivity, is the work of John Bowers (often with Sten-Olof Hellström). A typical project (Bowers and Hellström, 2000) develops four principles of 'interaction design' which differ considerably (especially when taken together) from those of Garzotto et al (1995). 'Algorithmically mediated interaction' separates out a 'layer' of algorithmic mediation which is distinct from 'direct manipulation' - often by capturing or storing input data for use 'out-of-time' - so that 'different peripheral devices, transformation algorithms, and sound models can be freely exchanged' (ibid). Input devices with a small number of degrees of freedom are used to allow 'expressive lassitude' - requiring careful algorithmic design to compensate for the small number of input data streams. (In Wanderley's terms 'divergent'- or 'few-to-many' mappings are used, but in combination with design principles which overcome his observation that such mappings 'do... ..not allow access to internal (micro) features of the sound object'. (Rovan, Wanderley et al.,1997) In further contravention of the principles enumerated by Garzotto et al.(1995), Bowers and Hellström use 'dynamic adaptive interfaces' which rescale or remap input over time such that the

³³ in currently unpublished research for ARiADA

interface's relation to sound changes dynamically, under algorithmic control. Finally, their concept of 'anisotropic interaction space' - where non-linear and discontinuous mappings are utilised so that the significance of movement over (for example) the two dimensional surface of a touchpad becomes context-dependent, allows the possibility that radically different interactive characters may emerge from the same device in a manner which is not wholly predictable, requiring real-time evaluation and adjustment on the part of the performer.

At a purely pragmatic level, as noted above, interactivity becomes an urgent issue simply because of the speed of the most recent generation of 'domestic' computer hardware³⁴, and the relative ease of availability of software for such platforms which allows and encourages real-time activity³⁵. In addition an increasing range of interfacing hardware allows increasingly personal solutions to the problems associated with the development of 'aesthetically significant' interactivity³⁶.

Endnote

This paper is intended as a starting point for debate and expansion. It is hoped that criticism and the further testing of these concepts in practice will lead to their refinement, and perhaps to their rejection and replacement by more appropriate analysis. In a continuation of the paper's ideas in a following edition of this publication I hope in particular to elaborate aspects of the argument relating to physicality, prosthesis and the bodily, taking as starting points the writing of Francisco Varela et al. (1991) and Barbara Maria Stafford's *Body Criticism* (Stafford, 1991-3). I hope to look in more detail at the notion of mapping, at issues relating to connectivity and diffusion, at re-use and recontextualisation of existing musical and aesthetic activity, and at the broad issue of hybridisation. As a marker of one composer's thought at the end of a millennium, I hope the current contribution will be of some value.

³⁴ Apple's G4 range of computers was classified by US export license requirements as 'supercomputers', a point emphasised at its launch by the company's publicity.

³⁵ For example Max/MSP and Supercollider. The former has already resulted in substantial texts detailing interactive applications of the language e.g. (Winkler, 1998)

³⁶ See ARiADA alumnus Neal Farwell's Harvard-based website (Farwell, 1999) for details of hardware, software and institutions with long-term research into interactivity, with web links.

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