Atoms and errors: towards a history and aesthetics of microsound*

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Microsound is an emerging approach to music composition and analysis which places emphasis on extremely brief time-scales, usually a tenth of a second or less, as well as an integration of this micro-time level with the time-levels of sound gestures, sections, movements and whole pieces. This paper summarises some of the technical issues involved in microsonic analysis/composition, traces a history of microsonic techniques in contemporary music, and examines some of its aesthetic implications in a social context.

1. INTRODUCTION

Microsound is an emerging approach to music composition and analysis which places emphasis on extremely brief time-scales, usually a tenth of a second or less, as well as an integration of this micro-time level with the time-levels of sound gestures, sections, movements and whole pieces. Individual micro-time events are integrated into larger sonic gestures, which in turn are integrated into entire pieces. The range of approaches to microsound include both institutionally produced computer music, as well as an increasingly popular and broad-based body of work from independent composers and sound artists with little or no formal training, connected in a virtual community on the Internet. In this paper, I want to attempt a relatively compressed history of the development of microsound, from its earliest inceptions, and instrumental and analogue precedents, to its more recent developments in the genre known as 'glitch' (Cascone 2000). I then want to pose the question of an aesthetics of microsound, and to the extent that it is mostly a digital phenomenon, this will mean asking the question of what constitutes a digital aesthetic, and further asking what kind of relation this aesthetic will have to the realm of the social. But first, some technical discussion is given to help us understand the theoretical basis of the techniques under review.

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2. TIME SCALES AND THE RELATIONSHIPS BETWEEN FREQUENCY AND TIME

Microsound can challenge many of our traditional conceptions about sound. For example, acoustics often conceives of sound in terms of either a frequency or time domain, while often failing to consider the relationships between the two domains. Traditional Fourier analysis, for example, treats sound as time-invariant sets of sine waves, thus privileging the frequency domain over the time domain, to the point where the latter is rendered all but irrelevant. Microsound, on the other hand, though often proceeding from within the time domain, often tends to highlight the tight interrelationship between the two domains, due to the brevity of the time scale involved. This can be seen, for example, in analysis involving Fast Fourier Transforms (FFT), where a small window size gives accurate time resolution, but poor frequency resolution, and a larger window size gives accurate frequency resolution, but poor time resolution. In other words, there is an uncertainty principle in the relationship between frequency and time, which is particularly noticeable at the micro-level. Much as in quantum physics, where the certainty with which one can determine a particle's position increases in direct proportion to the uncertainty that exists with regards to its velocity (this is the Heisenberg Uncertainty Principle), so '[p]recision in time means a certain vagueness in pitch, just as precision in pitch involves an indifference in time' (Wiener 1964: 544, quoted in Vaggione 1994: 77). Thus, far from being unrelated, time and frequency are tightly bound together, perhaps all the more so at the quantum level of micro-time, where the fundamental unit of time tends to be in the milliseconds or less.

This points to an integration of time scales in composition as being one of the distinguishing features of microsound. Herbert Brün, whose work is discussed below, expressed this integration as follows:

> For some time now it has [been] possible to use a combination of analog and digital computers and converters for the analysis and resynthesis of sound . . . This . . . allows, at last, *the composition of timbre, instead of with timbre*. In a sense, one may call it a continuation of much

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> that has been done in the electronic music studio, only on a different scale. (Brün 1970, quoted in Roads 2001: 30, emphasis mine)

Thus, rather than conceiving of synthesis and composition as two different domains, in microsound *synthesis can often be thought of as micro-level composition* (cf. DiScipio 1995), and often very similar or integrated processes are used on a variety of time levels within a particular piece. In this approach to a kind of total composition, some microsound resembles early attempts in the analogue electronic music studios of the 1950s to 'compose' sounds from sine waves superimposed on tape. But whereas these early attempts have been largely abandoned as too time-consuming and the sounds rejected as too lifeless and undifferentiated, microsonic techniques can yield much more satisfactory results because they proceed from an entirely different basis. Where the former proceeded from the basis of Fourier analysis which regards sounds in terms of their frequency content while neglecting their temporal morphology, microsound tends to proceed from an integration of a time-based and frequency-based understanding of sound, such that changes made on a micro-temporal level affects frequency content, or spectrum, on a higher level. There is thus a necessary relationship between the various time scales, as Xenakis argues:

> For a macroscopic [one might prefer the term 'macrosonic'] phenomenon, it is the massed total result that counts . . . Microsounds and elementary grains have no importance on the scale that we have chosen. Only groups of grains and the characteristics of these groups have any meaning. (Xenakis 1992, quoted in Roads 2001: 303)

In other words, changes made on the micro-level of sound design have effects on higher time scales as well, and there is a tight relationship between frequency and time, as noted above. This has led to an increasing tendency to emphasise the inseparability of material and form in much microsound-oriented computer music. 'Form . . .', wrote Gottfried Michael Koenig, whose work is examined below, 'is only illuminated by concretization, whereby it ceases to be an idea . . . [it can] only be discussed as the properties of the material' (Koenig 1987: 72, quoted in Di Scipio 1995: 40).

3. MICROSOUND'S DIGITAL BEGINNINGS AND EARLY PRECEDENTS

Microsound is predominantly a digital phenomenon, but there are important instrumental and analogue precedents. The impulse to use smaller and smaller elements as the starting point for musical production can perhaps be traced to a particular strain of modernism that could be said to have started with Webern's radical atomisation of his musical material. The Darmstadt and Köln schools of high modernism continued this radicalisation with increasing emphasis on the 'point' rather than the note as the smallest element from which a piece should be constructed (Stockhausen 1989: 33–42). Stockhausen extended this logic in his controversial article, '. . . how time passes . . .' (Stockhausen 1957; see also Koenigsberg 1991 and Roads 2001: 72–7, 78–81 for further discussion; and Backus 1962 and Fokker 1968 for critiques of the non-standard use of acoustics terminology in this essay), which posits an essential continuity between the domains of rhythm and pitch, where rhythm is simply sub-audio pitch and pitch is audio-rate rhythm; timbre is thus a superimposition of audio-rate rhythms. 'The concept of unity in electronic music' (1962) extends this theory further. This theory was actualised in Stockhausen's analogue electronic piece *Kontakte* (1960), which uses impulse generators in conjunction with other studio equipment to construct sounds (Roads 2001: 69). Similarly, Henri Pousseur uses filtered noise bursts in *Scambi* (1957), an early analogue electronic piece which lays ground for later microsound experiments. Michel Chion (1982, quoted in Roads 2001: 82) mentions the use of micro tape splices as a way of producing 'tight mosaics of sound fragments' and 'sounds that were reduced to the dust of temporal atoms', citing Pierre Henry's *Vocalises* (1952), Pierre Boulez's *Etudes* (1951), Stockhausen's *Etude Concrète* (1951) and Olivier Messiaen's *Timbre-Durées* (1953). Similarly, in Iannis Xenakis' *Analogique B* (1959), tiny tape splices are used to produce a primitive granular synthesis. In his *Concret PH* (1959), this approach is enriched by applying the tape micro-splice technique to a sound which is already granular in character: smouldering charcoal. These tape pieces followed up on Xenakis' proto-microsonic instrumental music, such as *Metastaseis* (1953), in which cloud-like textures are built up from atomistic instrumental elements.[1] Not coincidentally, Xenakis is perhaps the first to use the term 'microsound' (see Xenakis 1971, ch. 9). His later contributions to digital microsound will be considered below.

Despite these precedents, the predominant factor in the emergence of microsound was the development of digital technology, particularly 'software synthesis', or the direct synthesis of sound from individual digital samples. Microsound is in some ways more idiomatic to the digital domain than to the analogue domain (let alone the instrumental domain), since samples and groups of samples are more easily moulded into microsounds than are the continuous fluctuations in voltage produced by analogue electronics, and computers can more easily facilitate the kind of micro-level control which characterises many approaches to microsound.

[1]The 'micro-polyphony' of Ligeti's works from the 1960s onward could also be cited as a parallel influence.

Thus there is a technological determinant to the fact that digital microsound began to emerge when it did; it depended on the development of adequate digital technology. However, this technology did not exist in a vacuum; there were other aspects to the development of that technological base. For example, early digital microsound was produced at research institutions, both academic and non-, since these were the only institutions which had access to the necessary technology. Without this enabling institutional framework, none of the software or hardware designed for musical purposes could have been developed. Further, while much of the technological base of microsound was produced by these institutions for purely musical applications, it is also worth noting that much of the computer technology required for the production of microsound was originally developed for corporate or military applications. Thus, a large part of the socio-economic dimension of microsound's technological base was provided by the institutions of (predominantly Western) capitalism and the military-industrial complex (and this may be equally true of computer music generally; in any case, the links between computer music and the military have often been uncomfortably close; see, for example, Born 1995: 159–63 and Born 1996). While these are not the only institutions capable of providing the technological base for the development of computer music technology, it seems likely that much of this technology would not have developed in the same way without it. I say this not to question the value of computer music, but to draw links between its production and broader socio-economic institutions, since these links may tend to get lost in the abstraction of the 'purely' digital domain.

With these contexts in mind, we can look at some historical examples of early microsound techniques. One of the first instances of direct digital sound synthesis was Herbert Brün's computer music system SAWDUST. Developed at the University of Illinois in the mid-1970s by a team of programmers, it is a hierarchical approach to software sound synthesis, building sounds and structures from the bottom up, starting on the level of the sample (Blum 1978; Roads 1996: 324–6). The metaphor for this approach is provided by the system's name itself: the computer is the saw, and the samples are the dust. However, in this system, the 'saw' does not simply generate the 'dust', but moulds it into larger structures, on the level of everything from the sound event to the large-scale structure. This moulding is accomplished by a series of operations (LINK, MINGLE, MERGE and ARRAY; see Blum 1978) on sets of samples. The resulting music is hard-edged and often unpredictable, though restricted to a limited range of timbres. A recent CD (see Brün 2001 in Discography) showcases the possibilities of this system.

A related approach is G. M. Koenig's SSP (Sound Synthesis Program), designed in 1972 and developed by Paul Berg at the Institute of Sonology (then in Utrecht, now at The Hague) in the late 1970s (Koenig 1980: 121; Roads 1996: 326–7; see also Berg 1978). Koenig had anticipated the concept of working with sound on a microlevel as early as 1959 (Koenig 1959, quoted in Roads 2001: 83). Koenig conceived of microsonic approaches as an attempt to escape conventional models of sound generation in order to begin again from a new conceptualist and experimental method with no necessary basis in acoustic principles (Roads and Strawn 1985, quoted in Roads 2001: 30).[2]

Coming out of Koenig's previous programs Project 1 and Project 2, developed for the algorithmic composition of instrumental music, SSP essentially extends the principles below the threshold of the note to the level of the sample, moving from composition to synthesis. SSP uses two kinds of basic material: 'elements' (samples) and 'segments' (interpolated lines between two sample endpoints; several segments could be used to make up a complex waveform). The program, operating in real time (Berg 1978: 2), makes selections from a composer-specified database according to a number of principles: aleatory, serial, probabilistic, tendency masks, sequential, and random (Roads 1996: 326). Unfortunately, I know of no recordings of pieces composed using the SSP program. However, given the program's similarity to Brün's SAWDUST, one can infer that the program's sonic output might be similar. Certainly it is a highly conceptual approach to synthesis/composition, using no known acoustical model as its basis, probably resulting in highly synthetic-sounding and hard-edged timbres. In a 1979 interview with Curtis Roads, Koenig said that non-standard synthesis approaches like SSP mean 'not referring to a given acoustic model but rather describing the waveform [directly] in terms of amplitude values and time values' (Roads 1985: 572). Thus, these microsound approaches are specifically digital, impossible to realise any other way; they avoid the goal of emulating, modelling or imitating any other instrumental or electronic paradigm. Indeed, Koenig expressed impatience with the use of computers for

[2]A number of pieces of computer music software designed by Utrecht alumni were similar to SSP. One was Paul Berg's ASP, which later developed into PILE, a programming language (as opposed to a program) which generated sound in real time (see Berg 1977, 1979). Another was Steven R. Holtzman's software system which he described as 'an automated digital sound synthesis instrument' (Holtzman 1978). This system generated sounds and structures according to generative grammars and using logical operations on individual samples. A later version of similar software is described in Holtzman (1994), ch. 15. A similar 'synthesis-by-rule' approach, though not developed by a Utrecht alumnus, is Arun Chandra's 'wigout' program (Chandra 1994), which works by using stochastic formulae to manipulate waveform segments. It was originally written for Unix, but is now available for PCs (http://grace.evergreen.edu/~arunc/) with a Mac version developed in Max/MSP by Tad Turner.

anything but purely digital ends (Roads and Strawn 1985: 573).

More importantly, though, both SSP and SAWDUST, in their direct use of the sample as the fundamental musical element, may represent the consummation of the Western modernist impulse towards the atomisation of musical material and control of that material on ever-lower levels. Perhaps these approaches to microsound represent a continuation of the logic of Webernian musical modernism into the micro-level, extending from the domain traditionally associated with composition to the usual domain of synthesis. It is no accident that both Brün and Koenig emerged from the Köln/Darmstadt tradition of composition which often strove for control of sound on the lowest possible level (Roads 2001: 30).

A similarly 'atomistic' approach is evident in granular synthesis and granulation (see Roads 1996: 168–84 for more on these techniques). Granular synthesis usually begins from arbitrary waveforms, whereas granulation refers to the process of splitting a sampled sound into a series of grains, which can be layered and shaped in a variety of ways.

Let us first look at granular synthesis. Although Xenakis experimented with granular synthesis and granulation using magnetic tape (*Analogique B* [1959] and *Concret PH* [1962]), two names are most closely associated with the development of granular synthesis in the digital realm: Curtis Roads and Barry Truax. Of the two, Roads was the first to implement it at the University of California at San Diego in late 1974 and early 1975. Roads was inspired by Xenakis' idea of 'elementary sonic particles' (Xenakis 1992: 43–4) to implement this heretofore theoretical approach to sound generation on the computer technology available to him at UCSD. Though his first etude, *Klang-1*, individually specified each grain in a 'bottom-up' manner, in later granular pieces, Roads used a more efficient top-down approach used to produce clouds of grains from high-level specifications (similar to compositional processes of Xenakis and Stockhausen). His eight-minute piece *Prototype* uses this technique and is perhaps the first full piece made using granular synthesis. He went on to develop several programs for granular synthesis and granulation of sampled sound, including *Synthulate*, *Granulate* and *Cloud Generator* (developed with John Alexander at Les Ateliers UPIC) and used these techniques in subsequent pieces (see Roads 2001: 108–10, 302–10).

Roads' efforts were largely non-realtime. Michael Hinton of EMS in Stockholm implemented a real-time granular synthesis system in the late 1970s (Clarke 1996: 108–9). Independently, Barry Truax developed a real-time implementation of granular synthesis (1986) and later, granulation of sampled sound (1988). *Riverrun* (1986) is perhaps the first well-known piece using the technique of real-time granular synthesis, in which the river serves as a metaphor for this technique (a powerful entity composed of countless drops, which are trivial in themselves) (Truax 1987, 1990a, 1990b, 1990c, 1992, 1994a, 1994b, 1996a). Granulation came to figure prominently in Truax's approach to what he calls 'soundscape composition' (Truax 1996b, 2000b, 2001, 2002), an approach to music composition based on a concern for the sonic environment and 'acoustic ecology', as well as on a theory of the relations between the inner ('musical' or 'textual') and outer ('extra-musical'/contextual) levels of music (Truax 1994c). These concerns may arise primarily out of his involvement with R. Murray Schafer's World Soundscape Project in the early 1970s (Schafer 1970, 1977, 1978; Truax 2001). He is thus one former student of the Institute of Sonology whose work is less concerned with being 'specifically digital' in an abstract way, although it is certainly reliant on digital technology for its realisation. Indeed, it was his experience at the Institute which made him aware of the shortcomings of such an abstract approach:

> . . . in Utrecht, working on the computer and in the studios in the middle of an extremely noisy European city, the contrast between the refinement of sound, all of the abstract thinking that we were doing in the studio and how crude the sound was in the actual centre of the city, was to me pretty shocking. And [R. Murray Schafer] was cutting through that and saying we should be not just in the studio; we should be educating the ears of everyone who experiences the impact of noise. (Truax 1991)

Truax thus offers one possible way that microsound can explicitly relate itself to its social context and advocate a greater respect for the acoustic environment. By demonstrating the inner complexity of environmental sound and its potential to create musical meaning, Truax's work implicitly makes a case for the preservation of the acoustic environment.

While Truax is a Utrecht alumnus who pursued a path diverging from Koenig's digital purism, Xenakis' work in the realm of microsound is an example of how the Utrecht aesthetic resembles the work of composers outside of the Institute of Sonology. Among Xenakis' major contributions to the field of microsound is his GENDYN system, which consists of software for the direct digital synthesis of sound. The GENDYN system was based on Xenakis' long-standing dream of 'composing' timbres using the same stochastic (probabilistic) laws he had long used for formal constructions on the macro level; GENDYN was an attempt to integrate the micro- and macro-levels of musical time, and to treat synthesis as a kind of microcomposition. The program constructs waveforms using waveform segments computed from random walks (Serra 1993: 240) and modulates them using stochastic algorithms (Harley 2002: 54). On the macro-level, GENDYN operates very similarly to Xenakis' earlier ST program, which generated his ST series of works (*ST/10*, *ST/4* and *ST/48*, for example) (Serra 1993: 250, 253, 254). Three pieces (*GENDY301* and *GENDY3*, both from 1991, and *S709* from 1994) are, to my knowledge, the only ones composed with GENDYN, although Peter Hoffmann has re-engineered the program (Hoffmann 2000) and is in the process of preparing a dissertation on Xenakis' work in stochastic synthesis.

More recently, the influence of composers such as Xenakis has extended to a younger generation. Agostino Di Scipio has followed Xenakis' lead in synthesising sound directly from complex mathematical formulae, but has taken his inspiration not from stochastic and probabilistic mathematics, but from the current interest in iterated nonlinear functions, of which fractals are an example, and which derive from the study of nonlinear dynamical systems ('chaos theory') (see, for example, Gleick 1987 for a popular and canonical survey reference). In Di Scipio's *kairós* and *Zeitwerk*, for example, granular synthesis algorithms are controlled by iterated functions, resulting in complex modulations of parameters (Di Scipio 1994: 139). Later, Di Scipio worked with converting iterated functions directly into sound via a DAC (Di Scipio 1996, 2000). Like Xenakis, he attempted to employ the same methods in sound design as in formal construction, in an effort to elide the distinction between form and material which computer music has perhaps inherited from instrumental music (Di Scipio 1995). More recently, Di Scipio has made connections between this approach and the chaotic spectra of environmental sounds (Di Scipio 2002a, b).

4. OTHER RECENT DEVELOPMENTS: 'CLICKS AND CUTS' AND 'THE AESTHETICS OF FAILURE'

Parallel to many of the developments in microsound described above was the development of personal computers, and a corresponding paradigm shift in the production of computer music. The increasing power and sophistication of these machines has, since the early 1990s, been drastically reshaping the institutional framework of computer music production. No longer is institutional affiliation required in order to have access to a machine powerful enough to generate and manipulate high-quality digital audio. The kinds of software-based synthesis discussed above are becoming increasingly common on consumer-oriented machines. Indeed, recent high-end personal computers are often more powerful, not to mention generally more 'user-friendly', than some institutionally based machines from ten years ago. Thus, anyone who can afford the rapidly dropping price of a personal computer (though this is, as in the case of institutional computer music, usually relatively affluent white males) can have access to enough computing power for the production of very sophisticated computer music.

The corresponding rise of the Internet and, in particular, the World-Wide Web (WWW), further assisted the shift in computer music production, providing easy and often free access to information, software, a virtual community for discussion of various issues related to the new computer music composition, file-sharing, artist websites, and online record labels offering home-burnt CD-Rs or merely downloadable sound files. The introduction of high-powered portable laptop computers also created new rituals of performance, enabling performers to carry their studios in their backpacks from gig to gig.

Though most of this new work is produced on personal computers in a non-institutional context, it would be wrong to say that this new paradigm unfolds completely outside of conventional computer music institutions. Different composers and producers within the new paradigm have different degrees of awareness or affiliation with the usual institutional framework of computer music production, but most of them approach the latter framework from an outsider's perspective. This is partly because the new approaches to computer music production have yet to be taken seriously by research-based computer music institutions, though this is beginning to change. The publication of Kim Cascone's article on the new microsound in the *Computer Music Journal* (Cascone 2000) was one of the first steps. More recently, *Organised Sound* published an issue with several articles on this new music (see, for example, Sherburne 2002; Shirt Trax 2002; Szepanski 2002; Thaemlitz 2002), and the Ars Electronica festival has shifted its scope from 'computer music' (in the conventional sense) to 'digital music' which is more open to computer music produced within the new paradigm. Still, the relation between the institutional and new paradigms is somewhat uneasy; Curtis Roads' book on microsound (Roads 2001), for example, contains almost no mention of producers working within the new paradigm, focusing instead mostly on work produced within conventional research institutions. Whatever the reason for the omission, it seems symptomatic of the gap that still exists between the two approaches.[3]

The new genre of microsonic computer music tends to have a different aesthetic than computer music

[3]Since originally writing this article, the gap has narrowed somewhat, with the mostly non-affiliated composers of the.microsound email list (www.microsound.org) studying Roads' *Microsound* and making use of such techniques as waveform segmentation synthesis and synthesis using impulse responses (*à la* Stockhausen in *Kontakte*) in collaboratively produced mp3 projects (see http://www.microsound.org/stoneripple/ and http://www.microsound.org/klanghausen/).

produced within the traditional institutional framework. Although it is often informed by currents in twentieth-century concert music (Cascone 2000 cites John Cage and Luigi Russolo as influences) and art (Duchamp's ready-mades may also be at least an indirect influence), much of it is also in more or less explicit reaction to the predominant form of electronic music in pop culture, which is rave-oriented techno. The reaction can either be favourable or negative, but much of this music is beat-oriented, engaging microsonic sound design in its vocabulary of blips and clicks used in place of the usual drum-machine sounds. The presence of these elements, sometimes creatively derived from computer malfunctions, has earned this music the moniker of 'glitch', or, in the words of a popular (and by now formulaic) series of compilations on the Frankfurt-based Mille Plateaux label, 'clicks and cuts'. The click is thus, as Philip Sherburne writes, both a complaint against the betrayal of digital audio . . . :

> The click is the remainder, the bit spit out of the break. The indigestible leftover that code won't touch. Cousin to the glitch, the click sounds the alarm. It alerts the listener to error. The motor fails, the disk spins down, and against the pained silence there sounds only the machinic hack of the click. It is the sound of impatience at technology's betrayal, fingernails tapped on the table waiting to reboot. It is the drumming against the thrum of too much information . . .

. . . and a reaction to techno:

> . . . if pop and dance music aim at the perfect simulation of the Real by electronic means, then clicktech, microhouse, cutfunk graft a secondary structure onto the first – not imitative or hyperreal, but substitutive, implied, made clear by context alone: a compressed millisecond of static stands in for the hi-hat, recognizable as such because that's where the hi-hat would have been. (Sherburne 1998)

In other cases, the new microsound is beatless and focuses on textures often assembled from microsonic elements, again often culled from computer malfunctions or from the creative misuse of technology. This focus on the inherent errors and 'backdoors' in the digital audio medium has led Kim Cascone to name 'the aesthetics of failure' as a prominent aesthetic tendency in this new music. Cascone's own work, however, often also seems informed by tendencies within institutionally based computer music. His *Pulsar Studies* (2000), produced using Curtis Roads' *Pulsar Generator* software, is a series of short pieces based on creative uses of granular techniques and the creation of new and unusual granular textures. His recent *Anti-Correlation* (2002) makes use of the same kind of stochastic synthesis algorithms used by Xenakis (the sound files for the piece were actually produced at CCMIX using Xenakis' software). His *Dust Theories* (2001) uses a MAX patch which can pseudo-randomly select sound files in a given directory and shred them in unpredictable ways, enabling real-time performance capability, but within a non-deterministic framework (Twomey 2002: 21).

One common tendency in this new microsound is sometimes known as 'databending': the use of raw computer data for sound synthesis. At least one email list exists that provides a forum for discussion among such 'data-benders': <http://groups.yahoo.com/group/databenders/>. The Australian artist Pimmon has worked extensively with sound synthesised from raw computer data, basing pieces on program files or dynamic link libraries (.dll's) converted into sound files; *Electronic Tax Return* (2001) is one release of many to make use of this technique. The interchangeability of digital information (text becomes image becomes sound becomes . . .) has been exploited by other artists in similar ways, thanks to the availability of (in)appropriate software tools. These interchangeabilities allow one to manipulate sound files in an image editor, or text files in a wave editor, enabling new forms of production and aesthetic effects resulting from a structural characteristic of the digital medium itself: its composition from neutral and trivial bits which can be arranged in a variety of data formats.

In a similar creative (ab)use of technology, 'glitch' music often bases itself around the microsonic errors that are inherent in digital audio. The artist who has perhaps made the most consistent use of these glitches is the German producer Oval (a.k.a. Markus Popp). A work like *Systemich* (1996) contains dirty digital ambience backed by Oval's signature sound: rhythmically skipping CDs. Oval paints pictures on the bottoms of CDs in order to force them to skip and then samples and loops the result, forming both an abstract layering of skittering glitchy rhythms and an implicit jibe at the digital triumphalism spouted by corporate marketing managers who make it their job to hawk a supposedly flawless digital audio to a ravenous consumer public. Oval's techniques are related to those of Yasunao Tone, whose 1997 *Solo for Wounded CD* also makes use of the sound of skipping CDs. Oval and Tone seem to have arrived at their creative misuse of CDs by different paths.

5. A 'DIGITAL AESTHETIC' AND 'THE POLITICS OF DIGITAL AUDIO'

> Aesthetics *is* politics . . . a set of cultural and social values . . . (The late Cuban-born New York artist Felix Gonzales-Torres)

The 'aesthetics of failure' in 'glitch' music offers us a way in to a discussion of aesthetics in microsound in general. What kinds of aesthetical approaches or theories could accompany the variety of approaches to microsound composition? As mentioned, microsound seems to be an almost exclusively digital realm, despite its instrumental and analogue electronic predecessors. Perhaps, then, some discussion of a 'digital aesthetic' – or at least some exploration of the relationship between 'the digital' and 'the aesthetic', and the different meanings of that relationship for different producers – may be in order.

Some of the composers of the Utrecht school have given us one model of what a digital aesthetic might be like. For Koenig, a 'non-standard' approach to sound synthesis (he is referring to his waveform segmentation technique described earlier) is the most idiomatic – and thus, in a way, the most 'correct' – use of the computer for sound synthesis. Computers should be used only for 'computeristic' purposes, and composers should tailor music to the specific capabilities of computers:

> We should rewrite music theory in binary terms. Create a new grammar for computers. Something which is adapted to the kind of systematic thinking of the computer world. Nothing vague. Either 0 or 1. (Koenig quoted in Holtzman 1994: 241)

Paul Berg, whose computer language PILE is discussed above, likewise argues for a specifically digital approach to music with the computer:

> [All sound synthesis programs] require the use of a computer because of the magnitude of the task [of digital sound synthesis]. For many [people], this is perhaps the only reason why they require the use of the computer. It is a valid reason, but it is certainly not the most interesting one. More interesting reasons are:
>
> to hear that which without the computer could not be heard;
> to think that which without the computer could not be thought;
> to learn that which without the computer could not be learned . . .
>
> Computers produce and manipulate numbers and other symbolic data very quickly. This could be considered the idiom of the computer and used as the basis of musical work with [it]. (Berg 1979: 30)

And Steve Holtzman, yet another Utrecht alumnus, also argues for a specifically digital aesthetic. 'What means of expression are idiomatic to computers?' he asks (Holtzman 1994: 240; see Holtzman 1997 for a fuller discussion). For Holtzman, the answer is a kind of 'digital expression', a mode of expression made possible only by computers. For all these composers, then, a digital aesthetic is one which arises from the specific aesthetic capabilities of the digital medium. The structural characteristics of digital audio itself – its 'informationality' or 'numericality' (structurally, digital audio is information in the form of numbers), its composition of individual and discrete bits or samples, the ease with which one can perform long series of complex calculations on these bits, the facility it provides in working on the microtemporal level, etc. – form the structural basis of a 'proper' aesthetic for computer-based music. Techniques like wavetable synthesis or the simulation or analysis/resynthesis of conventional instruments or sounds should, on this view, be shunned in favour of sound production from a purely digital basis, with no foundation in acoustical principles or even, it would often seem, reference to the external world. Like structural film, in which the filmic medium itself becomes the subject of the work, this approach to a digital aesthetic is precisely an aestheticisation of the digital. In this sense it continues a modernist tradition of abstract formalism and self-referentiality; for Koenig, 'Schönheit ist Formache' ('Beauty is a matter of form') (quoted in Holtzman 1994: 256). It is worth noting here how Koenig's embrace of the binarism of digital technology is perhaps fundamentally modernist, since that binarism is, as Brady Cranfield argues, 'the virtual embodiment of Western rationality' (Cranfield 2002: 42). Though it is true that much modernist cultural production emphasises irrationality and illogic, I am thinking here of what might be characterised as the formalist strain of modernism to which I see Koenig belonging.

In contrast to the modernist areferentiality of much microsound, while still working in ways specific to the digital medium, many composers reject the idea that a digital aesthetic necessitates formalism and abstraction. For Di Scipio, the direct synthesis of sound from iterative nonlinear functions can be used to allude to, if not to model, environmental sounds (Di Scipio 2002a, b). For Damián Keller and Barry Truax (1998), granulation can offer not just a way to model environmental sounds, but a model of how environmental sounds can often themselves be understood as granular. Further, the role of digital technology in our complexly mediated world can itself provide a basis for that technology's role in the construction of what Truax calls a 'contemporary myth'. His extended music theatre work *Powers of Two* (1995–1999), like his one-time teacher Koenig's work, foregrounds its own 'digitality' in its title (which refers to the binary character of digital technology), but that title also refers to more complex dynamic relationships between pairs of opposites (gay/straight, synthetic/natural, etc.). Also, the piece could be said to manifest a 'digital aesthetic' insofar as it incorporates techniques that are only made possible with digital technology. Further, underlying not only *Powers of Two*, but also his soundscape work with granulation, is a view of musical complexity in which music as a text highlights (or 'sounds out' to use a sonic metaphor) its relations to its social and environmental context (Truax 1994c, 2000b). To borrow Roads' terminology, not only does Truax integrate the microsonic level with the level of the sound object, meso- and macro-level in a way which Di Scipio (1995) claims can elide the distinction between synthesis and composition, but his music also aspires to integrate itself with the supra time level of history, society and politics and nature.

Some have argued that the new genre microsound also relates itself to its own social context in the development of a digital aesthetic. Brady Cranfield (2002) argues that Oval's music constitutes not only a critique of the supposed infallibility of digital technology, but also a disruption of the technological mastery on which corporate music entertainment depends (Cranfield 2002: 46). For Cranfield, Oval's work constitutes not just an aesthetic challenge or technological critique, but a broader politico-economic gesture, insofar as any aesthetic or technology exists within the framework of a political economy. Further, Oval's work could be said to constitute a digital aesthetic insofar as it indicates that digital technology creates not only new possibilities for aesthetic production, but like any new technology, also opens up new possibilities for error and malfunction, a fact conveniently omitted from most of the marketing rhetoric surrounding the production and consumption of digital technology. Perhaps nothing is so well suited for a critique of digital technology, and its attendant political economy, as digital technology itself, used in a way that 'sounds out' all the new errors which inevitably accompany a new technological paradigm.

Kim Cascone (2000) mentioned Oval's work in his paper on 'the aesthetics of failure'. Curiously, however, Cascone refers to this aesthetic tendency as 'post-digital', despite the fact that this music is digitally produced. But for Cascone, perhaps the post-digital is to the digital as the postmodern is to the modern. Much as postmodernism is not so much what comes after modernism as what comes out of it, as modernism's self-conscious critique of itself, 'post-digital' refers to work which inhabits the cracks in the digital dream, seizing on usually marginalised digital detritus and forging a new aesthetic from technological error. Parallel to Schönberg's 'emancipation of the dissonance', post-digital music may be at least partly about the emancipation of the glitch. But, as Ian Andrews (2002) argues, the post-digital may tend towards its own kind of neo-modernism, perhaps recalling the abstract formalism of, for example, the Utrecht school. It's a short step from basing music and sound art on the errors inherent in digital technology to evacuating the work of anything but those errors, and thus reproducing the purism and formalism of modernity. Though it is true that there are a variety of approaches to 'glitch', from the noisy Dionysianism of Oval to the post-digital Apollonian purism of Taylor Deupree, Andrews argues that all of them are at risk of falling into the neo-modernist trap:

> I don't think that the aspect of the glitch as critique in the form of self-reflexivity is enough to save it from pure art. This is why [in Andrews (2002)] I brought up the comparison with structural-materialist film. Those film-makers sought a political cinema practice concerned with the materiality of the filmic substrate, but ultimately ended up reproducing the same essentialist problematics as [American post-war art critic Clement] Greenberg and high modernist painting. (Andrews in a 13 December 2002 posting to the .microsound e-mail list)

This is one way in which I would argue that the 'aesthetics of failure' might be on its way to being simply a failure of aesthetics. Though this (post-)digital aesthetic may have originally entailed some level of technological critique, the logic of that critique may have been extended to the point where its critical spirit may be vanishing. Its techniques may also be on their way to becoming as formulaic as those of the techno against which it originally railed. More and more audio software is being developed which enables one to simulate the sounds of digital failure without actually experiencing it. Digital technology is rendered capable of *successfully* emulating its own *failure*, a fact which risks undercutting whatever critical edge an aesthetics of failure may have had. Additionally, as Cascone (2001a) argues, the lack of external references and influences in post-digital music can lead to a rather static aesthetic situation which resists self-criticism and development. Many post-digital producers listen only to other post-digital producers, perhaps making for a closed system in which little real change can occur. Further, the lack of diversity to be observed among the producers of this critical aesthetic (microsound duplicates the predominance of white males found in most other areas of electronic music) runs the risk of creating a rather one-dimensional critique, in which questions of race, gender, sexuality, nation, colonialism, etc., are given less emphasis than the critique of the political economy of digital technology. The narrowness of this critical edge may be partly responsible for the aesthetic impasse into which glitch has headed. This is not to suggest that 'diversity' and/or 'inclusivity' are to be valued purely for their aesthetic consequences, but rather that empowering a broader range of producers may, as one of its many desirable consequences, result in a broadening of its critical relevance. And finally, the increasing commercialisation of glitch means the critique is being co-opted and sold back to those who produced it in the first place. Oval's music, for example, was recently featured in a Dutch advertisement for Armani designer clothing. Even the Frankfurt-based post-digital counter-culture label Mille Plateaux has begun to cash in on the success of their 'Clicks and Cuts' series of compilations, having just released the third volume, leading one frustrated observer on the .microsound list to observe that '"Clicks and Cuts" is becoming the 'Rocky' of digital audio'. It is not clear to me that the post-digital aesthetic should be abandoned for these reasons, but perhaps it is time for it to re-invent itself in a way that offers a way past the impasse which its own self-consciously limited vocabulary has tended to produce.[4]

In reviewing these different versions of a '(post-) digital aesthetic', it has not been my purpose to come to a single conclusion, nor to suggest that one may be more correct than any other. Rather, they can inform each other. Glitch and post-digital tendencies may benefit from a broader range of influences, including those stemming from research-based computer music institutions, to find their way out of the current aesthetic deadlock into which they seem to be heading, and institutionally-based composers may also be able to develop new aesthetic directions with more of an influence from composers working outside the institutional framework. Indeed, this cross-fertilisation seems to be underway already, with institutionally based composers becoming more and more aware of the new tendencies in digital music (though the reaction is not always favourable, if the response to the paradigm shift at Ars Electronica is any indication). And more and more tools from research-based institutions will likely become available to a broader public, in much the same way as has granular synthesis, so that it may be possible for non-institutionally based composers to work with the kinds of waveform segmentation techniques or stochastic synthesis that only composers like Koenig or Brün were using several decades ago.[5] Glitch thus seems to be following a similar trajectory as that followed by minimalism in the 1960s and 1970s. Minimalism, a movement in music begun by Glass, Reich, Riley and others, originally took place outside the conventional music-institutional frameworks of the university and the conservatory, but was gradually assimilated into those frameworks to become part of the vocabulary of contemporary concert music, all while its vocabulary was also being commercialised by pop groups like Tangerine Dream. Similarly, glitch, as a movement which began outside a musical-institutional framework, also seems to be following this twin trajectory of institutionalisation and commercialisation, and what becomes of that genre will be determined by how it responds to these tendencies. Certainly there is already beginning to be a reaction against the perceived over-seriousness and self-importance of glitch; artists like Kid 606 are returning to a dance-based and hedonistic post-glitch corporeality in reaction against what is perceived as a plethora of geeks staring into their laptops and emitting a standard minimalist vocabulary of glitches and digital noises.

Microsound produced at research-based institutions also seems to be on its way from being a relatively marginal and esoteric current within computer music to being a more central tendency. The publication of Roads' book on microsound, and the increasing popularity of techniques like granular synthesis, among other trends, seem certain to increase the interest in microsonic techniques in the near future. And as the historical distinction between electroacoustic music and computer music begins to fade, given that more and more electroacoustic music is being produced with computers (Truax 2000b: 119), the digital medium and the microsonic techniques idiomatic to them will achieve a greater and greater degree of prominence. Soon, the idea of 'a digital aesthetic' may cease to exist in particular, since the aesthetics of electroacoustic music as such will pertain to the digital realm.

But whatever form a future digital aesthetic takes, one hopes that producers of digital music will begin to more explicitly think through the relationships between that music and the social realm. While computers may, by their abstract nature, encourage formal abstraction in computer-based music, they may also be increasingly socially relevant as a musical tool in a world in which everything from culture to globalised capital is becoming increasingly mediated by digital technology. Whereas the reaction of some glitch, according to Ian Andrews, has been to flee this mediated world into a 'pure' and insular self-contained datasphere of glitches (and Utrechtian modernist structuralism has pursued a similar path), digital music has the ability to play a central role in constructing the kind of relationship we want to have with this new technology which is in the midst of changing our world so drastically. There is no longer a space on the global stage, on either side of the 'digital divide', which is not now somehow affected by the reach of digital technology; from the first-world laptop geek to the 'Third-World' victim of 'structural adjustments' made in the service of digitised global capital, digital technology is increasingly not just a medium of cultural production, but also a vehicle for global relations of power and economics. Therefore, the computer may be the musico-political tool most able to speak to the increasing digitisation of global society and economics, though not without a healthy (and consistent) scepticism regarding its role as a critical tool; even a critical digital aesthetic can unwittingly become simply part of the marketing rhetoric of the 'information economy'.

[4] Since originally writing this article, I have become unconvinced that the 'co-optation' of glitch is necessarily a bad thing. Indeed, Tobias Van Veen has argued that glitch is relevant precisely because of its proximity to digitised capitalism, where homebrew, web-based CD-R labels share the same technology and the same bandwidth as e-commerce and online currency speculation. Glitch thus offers an alternative to these forms of capitalism, while nonetheless operating on their terrain.

[5] Indeed, as noted above, this is already happening on the.microsound list.

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