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Musical Creativity and Complexity at the Threshold of the 21st Century

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ABSTRACT

The author describes a paradigm shift in which current models of sound and music are replaced by models of complexity. In terms of sound, the shift moves away from linear (e.g. Fourier) models in acoustics and parameter response models in psychoacoustics towards multi-dimensional concepts of timbre, volume and temporal dynamic shape. In terms of composition, the shift is away from its literate and deterministic aspects, as well as the notion of art as abstract and context free. The result is a concept of music where sound and structure are integrated as well as music and context. Examples are drawn from the composer's work with granular synthesis and environmental sound composition.

THE END OF THE FOURIER ERA

As we approach the end of the century, a paradigm shift in our models of sound and music appears to be gaining momentum. Perhaps from the perspective of some future date this shift will be understood, like Thomas Kuhn's famous model of scientific revolutions (Kuhn, 1962), in terms of crisis and schism. However, at the moment the more appropriate metaphor is that a number of independent streams and rivulets appear to be converging into a powerful torrent that will sweep away the entrenched models we have inherited. On the other hand, the converging streams may simply form an alternative waterway that runs alongside the older course for awhile, only much later becoming the principal site of navigation. What seems more certain, however, is that the existing models of sound and music are ceasing to respond effectively to our needs. Change is both necessary and inevitable.

The models which I observe to have decreasing vitality are linear acoustic models, stimulus-response models of psychoacoustics based on independent parameters, what I will call "literate" models of composition, and notions of abstract, context-free art. The rate of their respective demise may be different, but I am becoming increasingly aware of a certain parallel trajectory in each seemingly distinct area. They all seem destined to be replaced by what I call *models of complexity*. And in each area, the computer, as the most powerful means we have at our disposal of simulating and controlling complexity, plays a key role.

At least three characteristics of the paradigm shift can be identified in terms of how the new models will differ from the older established ones. First is the emergence of non-linearity as a legitimate and ordering factor in the system. This shift has already occurred in the physical and biological sciences with tremendous impact through the emergence of non-linear dynamics, more popularly called "chaos theory" (Gleick, 1987). Typical of the impact has been the realization that non-linearity in even a "simple" system leads to complex behaviour (Truax, 1990b). The older worldview that the universe is basically linear with pockets of non-linearity which can be conveniently ignored, has been replaced by a view that the world is fundamentally non-linear, and that instances of linearity are rare or only approximations of reality. Strangely enough, the full impact of this shift has yet to reach acoustics, one of the oldest of the linear sciences. However, certain specific cases have been documented; recent work in woodwind multiphonics by Gibiat (1988) and Maganza et al. (1986) has shown that these sounds are the result of chaotic behaviour in the forced oscillation of the instrument.

Secondly, the notion that phenomena such as sound can have separable, independent parameters the responses to which can be studied individually is already a "classical" idea, but the effects of this model are still with us, and even promoted by electroacoustic technology. Instead, I see the paradigm shift as leading to models of inter-related parameters that result is complex percepts. Having used linear models for centuries to literally ex-plain phenomena, that is, to reduce their multiple dimensions by projecting them onto two-dimensional surfaces, it will take considerable conceptual and linguistic change to establish new models of complexity in this area.

Finally, I think the paradigm shift will result in new models of systems. Compared with the typical hierarchic concept of a system where each level simply accumulates lower levels which it controls (and here you can think of the structure of symphonic music, the orchestra that plays it, or society at large), the new model will be characterized by interacting levels, with messages and feedback between them, self-organization and massive parallelism. Such systems will also have a balanced relation with their environment; in fact, context will be seen as part of the system itself. The metaphor "organic" springs to mind, but that begs the question of how we model living systems, and diseases such as AIDS are clearly challenging current thinking in that area as well in terms of how a living organism recognizes itself and interacts with its environment. A new systems model in music and its processes will surely redefine the role of the composer or artist who until now has been seen as the mastermind of precisely controllable variables. The new paradigm will more likely see that person's role as a guiding element in a complex process that links artifact to context.

Timbre as an Example of the Paradigm Shift

Perhaps it is unfair to single out a particular individual as the prototype of a dominant model in decay, but I have described the paradigm shift as "the end of the Fourier era." Jean Baptiste Fourier, of course, was a mathematician who became famous for solving a particular problem of the decomposition of functions in the time domain in terms of their constituent frequencies. He probably could not envision its impact on acoustics over the next 150 years. However, his discovery was the key ingredient that has resulted in the Fourier model of timbre as the linear sum of simpler components.

In the simplest form of the model, the Fourier theorem or series, time dependence of the waveform is ignored and the result today is the ubiquitous role of the time invariant oscillator, and in digital systems the wavetable, as the unquestioned basis of sound synthesis, despite the fact that it is a poor model of acoustic reality. The early work of Mathews and Risset (1969), and later that of Grey and Moorer (1977), identified the presence of time dependent harmonic components in acoustic sounds, but the addition of this variable created a data bottleneck for resynthesis while failing to account for the natural complexity of the highly time-dependent parts of the sound such as its attack. The more general model, the Fourier transform, extends the basic concept by proposing means to convert one "domain" (frequency or time) into the other; however, it is computationally intense and unsuited for sound synthesis.

It is interesting to speculate why one model, the timeless Fourier-based fixed waveform oscillator, achieved its dominant role, despite its obvious aural deficiencies, while another that corresponds more closely to the auditory system languished on the sidelines. In 1947 the British physicist Dennis Gabor proposed an 'acoustical quantum' as the fundamental unit of sound that incorporates both frequency and time because "it is our most elementary experience that sound has a time pattern as well as a frequency pattern" (Gabor, 1947, p. 591). In other words, the quantum is the shortest duration of sound that will activate the auditory system. It is an event, not merely a fixed stimulus. Although the techniques of granular synthesis (Roads, 1978, 1988, 1991) depart from the ideal Gabor grains, they still involve the principle of building complex events from the seemingly trivial micro-level, enveloped quanta called grains. Today, now that granular synthesis has become feasible in real-time synthesis (Truax, 1988), its model of acoustic complexity is being explored with a great deal of aural satisfaction that was never accorded oscillator based synthesis. But the list of similar alternatives to the Fourier model to which it belongs seems surprisingly short (De Poli et al., 1991).

Acoustic theory seems to lag behind musical needs. The introduction of noise as potentially musical material has had a distinguished group of proponents throughout the century (Russolo, Varese, Cage, Schaeffer, R. M. Schafer et al.). However, acoustic theory has not dealt with sounds of this complexity to any extent, such as through standard techniques of analysis and resynthesis (Risset, 1991). Many examples of musical instrument and vocal sounds have been analyzed in this way, but few if any convincing examples exist of complex environmental sounds being similarly resynthesized. It seems that attention has been directed to only the linear cases which are amenable to solution within the dominant model. We need a new acoustics of complexity.

But the implications of the Fourier model don't stop with the choice of musical material. The emphasis on pitch and supporting timbre in instrumental music has promoted the concept of music as abstract. The increased importance of timbre in this century as the principal concern of certain types of music involves the composer in a new type of complexity – the world of gender, environment and culture (Shepherd, 1987). Unlike pitch-based music, the understanding and effective design of timbre depends on reference to all these real world variables.

Volume as a Complex Percept

In the world of psychoacoustics, another example of the dominant paradigm in crisis is evident with the psychophysical model of subjective loudness related to the objective intensity of a sound. At its root is the same reduction of a musical sound to its Fourier components, the measurement of their individual magnitudes in phons to account for the equal loudness contours of the auditory system, followed by the conversion of phons to sones to allow their linear summation according to a variety of schemes (Rasch & Plomp, 1982a). In order to deal with environmental noise (historically precipitated by the introduction of jet engines into the environment in the late 1950's), Kryter (1959) followed an analogous scheme that divided the broadband spectrum into narrow bands whose loudness in units of noys could be summed to form the PNdB measurement system (Perceived Noise in decibels). However, both of these systems seem to me to be the most unsatisfying aspect of classical psychoacoustics – both try to predict the psychophysical response to a sound's magnitude by summing the response to its components and interpreting the result as a single-dimension variable similar to pitch.

More seriously, I think, psychoacoustics has indirectly fostered the concept of loudness as an independent variable. The experimental practice of holding certain variables constant while varying others requires this kind of thinking. What operationalizes the concept is the electroacoustic practice of amplification whereby a sound's magnitude can be varied by any amount, even to the point where the auditory system can be damaged. It is useful to note that the electroacoustic concept of amplification (whose technology developed during the early years of psychoacoustics) represents a profound shift in meaning from the original acoustic concept (Truax, 1984, chapter 8). In an acoustic system, energy is limited to what is present in the initial driving force and amplification means improving the efficiency of its transfer (e.g. attaching the sound source to a resonator). By contrast, in an electroacoustic system, energy is constantly added and the result is a virtually unlimited possibility of sound magnification. Acoustic systems, as a result, are constrained, balanced and hence ecological; electroacoustic systems break free of the constraints of the physical acoustic world by converting sound to an electrical form. Hence they are largely unconstrained in their ability to dominate space and time, and therefore are inherently non-ecological unless carefully designed with new constraints.

Our experience with amplifiers sometimes makes us forget that in the acoustic world, loudness is *not* independent of other variables such as spectrum, space, duration or density. In fact, loudness is best understood as the *result* of the interaction of these variables. A richer spectrum, produced by more energy, results in a louder sound; a reverberant space also adds loudness; short sounds appear less loud than longer ones; and an additional number of sound sources produces increased loudness, as in an ensemble. Although psychoacoustics has documented these relationships, I think it has missed the larger picture of how everyday perception treats these variables together in a more complex percept.

The complex percept I have in mind is a term that has fallen out of favour in modern psychoacoustics, namely *volume*, which can be defined as the perceived magnitude of a sound (Olson, 1962, p. 260). It is the psychological "space" which a sound creates or occupies – the space in the sound. It is the result of a complex set of variables since it tends to increase with spectral richness (or resonance), reverberation, duration, and of course intensity. However, it is also a more stable variable than loudness in that it can survive perceptual ambiguities such as those created by distance. A sound may be quieter either because of distance or because its source is less intense. However, if its perceived volume remains large, we know that the sound is simply more distant. Similarly, two sounds may arrive with the same intensity, but we can distinguish between the closer quiet one and the louder distant one in the same manner as demonstrated visually by the famous Ames experiments. By assuming the invariant size of, for example, a person or object, we interpret the perception of lesser magnitude as evidence of distance.

Since the term "volume" suggests a three-dimensional space, what might its dimensions be? In the classical models, we have the conventional three-dimensional spectrum or sonagram representations where the axes are intensity, frequency and time. We have already argued that the concept that intensity and hence loudness is an independent parameter seems to be a bias of electroacoustic origin. An alternative proposal, one that might more adequately deal with the complexity of the perceptual variables, can be represented with three axes corresponding to spectral richness (such as the energy per critical band), time, and a variable I will provisionally call "temporal density" (Fig. 1). The parameter of spectral richness involves two variables, frequency and intensity, so technically the model includes four dimensions. Temporal density refers to the temporal spacing of independent spectral components such as multiple sound sources and phase-shifted or time-delayed events. In the case of a single sound source, we arbitrarily plot unsynchronized spectral components along the temporal density axis instead of at a delayed point along the time axis. The zero point on the temporal density axis represents a sound where all components are synchronized and time invariant.

In such a scheme, examples of sounds which have zero volume are the one-dimensional sound, the sine wave, which is represented as a straight line, and the two-dimensional sound, the fixed waveform, which occupies a flat plane. Each lacks any temporal density because neither has any temporally independent components. Unsynchronized frequency components are involved in any dynamic spectrum, and therefore such sounds have a perceived volume. Other unsynchronized components in the 1-10 ms range, such as those in choral effect and

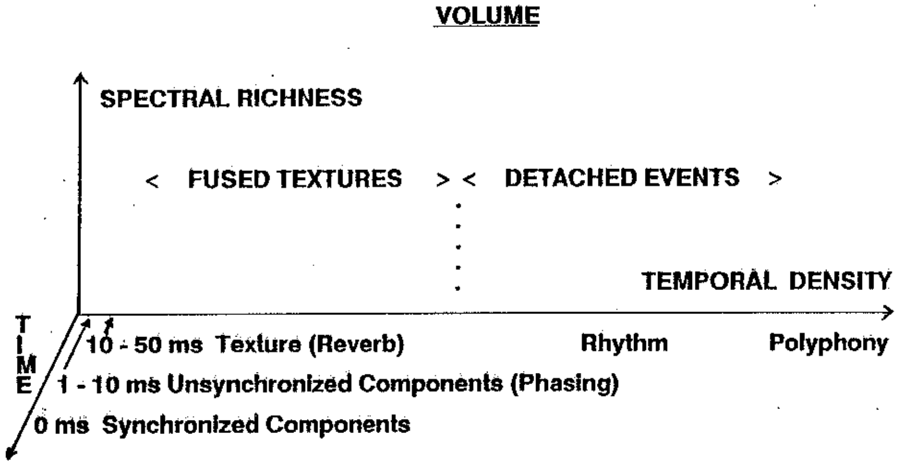

Fig. 1.

phasing, add increased volume. Components from 10-50 ms are typical of early reflections in the reverberant field which also add perceived volume (Rasch & Plomp, 1982b); likewise, independent sound sources occurring within the 50 ms limit create fused textures (MacKay, 1984). Beyond 50 ms lies the range of detached, separable events leading to concepts of streaming (McAdams & Bregman, 1979), rhythm and polyphony, all of which are suggestive of what might be called "musical volume" or "musical space."

Granular synthesis, applied to the processing of environmental sounds, permits a time shifting of such sounds that allows them to be slowed down, up to a thousand times or more, with no change in pitch (Truax, 1990a). The technique also increases the perceived volume of the sound without necessarily altering its pitch or loudness. First, there is the increase of spectral richness by the superposition of 12 or more versions of the source per stereo pair of tracks. Such overlays intensify bands of spectral energy whether those of formants or noise elements. Secondly, the simultaneous voices are normally not phase coherent with respect to each other because of the random synchronization created by the variable duration of the grains and the delay between them. This temporal independence of voices (in the range of phasing and reverberation effects, viz. less than 50 ms) also results in the composite sound seeming to have greater volume. Finally, the time-stretching technique adds a third dimension to the perceived magnitude, namely spectra that are normally brief instants in time can now occupy virtually any duration. The result is that even noise-like spectra (such as water or percussion sounds) are perceived as having larger-than-life vocal characteristics (Truax, 1991). Paradoxically, by linking frequency and time at the level of the grain, one makes them independently controlled variables at the macro level.

Even if psychoacousticians have abandoned it, composers and musicians seem to have intuitively absorbed the principle of volume and developed techniques to achieve it. Instead of producing perfectly sustained tones, a violinist uses vibrato and an organist produces tremolo to add complexity through micro level variations. Instead of a single performer playing louder, an ensemble of multiple sound sources is traditionally used to create the complex sound we call choral effect, and the result is increased volume. Careful architectural design of interior spaces adds reverberation, hence complexity and volume. In contemporary music, the desire to introduce texture into music by composers such as Ligeti, Xenakis and Penderecki can be understood similarly. Even early electronic music composers, faced with the extremely reduced dimensionality of sine wave oscillators found non-linear solutions to give sounds a greater sense of volume or solidity, e.g. Stockhausen's *Studie No. 2* where sine tone complexes were recorded in a reverberation chamber (Toop, 1979). Later analog synthesizer users became fond of the voltage-control filter which phase shifted the dynamically changing frequency components of the fixed waveform oscillators. Chowning's breakthrough with the non-linear FM synthesis technique invoked the non-synchronous evolution of sidebands according to the Bessel functions to achieve a more "natural" or "lively" sound (Chowning, 1973). Today, the popularity of digital delay units and digital reverberators testifies to the desire to hear sounds, particularly synthesized ones, with greater volume. These solutions proclaim the triumph of aural common sense over strict acoustic theory based on the Fourier model. But what if acoustic theory were to provide aurally satisfying models from the start, instead of forcing the composer to rely on the ingenuity of post-processing?

A new psychoacoustics of complexity will work with multi-dimensional concepts such as timbre, volume, and temporal or spatial dynamic shape, instead of the reductionist approach using independent parameters that can explain only simplified, artificial or unnatural aural phenomena. It was the hope of the reductionist view that complex events could someday be explained on the basis of elementary ones, but after 60 years this hope is largely unfulfilled. Steps in the new direction are already occurring, such as the use of the term "percept" as the basic unit of auditory activity, rather than the single parameter response characteristic. The paradigm shift I am referring to means starting with the complexity of the real world and dealing with it in a way that does not reduce its dimensionality.

THE END OF THE "LITERATE COMPOSER"

Much of the model of the composer which we have inherited (the one which reached its peak in the 19th century and persists today, at least psychologically) stems from the development of music, both in performance and composition, as a literate activity, as distinct from an aural one. This literacy, of course, is most closely associated with the use of notation and the consequent ability to "read" music. The planning and organization of abstract structures such as harmony and counterpoint in the Western tradition only became thinkable using an out-of-time representation such as the score. Current technology such as recording media and computer software also exist outside of time and have an equally powerful effect on the development of musical thinking. The transition in the Medieval world from the use of notation as a mnemonic device (the literal meaning of "neumes") to a prescriptive set of coded instructions available only to those who could read them, lead to the rise of polyphonic music. The role of memory in this transition was similarly altered. Oral music is memorized, often in vast quantities with extreme accuracy and amazing longevity. The score replaces this internal memory with an externalized one where what is learned is the visual code whereby endless "new" music can be deciphered and re-created – and also forgotten.

Electroacoustic technology in the 20th century for both sound production and re-production has undermined the literate aspect of notated music, in much the same way that electronic media have contributed to the decline of the influence of print. Ironically, computer music technology is often used to serve the notation-based composer by creating software analogous to word processors that might be called "note processors." It is clear that technology by itself doesn't necessarily precipitate a paradigm shift. New ideas lead to new technology, but new technology doesn't always lead to new ideas. The vast range of musicians using the computer today extends from the pop music composer, for whom MIDI sequencer software is a faithful scribe, to for instance G. M. Koenig who exploits the computer's ability to participate in the compositional process by using programs as a way of formalizing new concepts of musical language. These examples serve as a reminder that instrumental music, scores or computers by themselves do not exclusively define what constitutes the literate composer. The paradigm shift involves the musical process, not the artifact or tool.

Laske (1989) characterizes the crucial shift in 20th century musical thinking as that from model-based to rule-based composition, with the involvement of the computer as the most powerful tool for exploring the rule-based approach. Model-based composition relies on the analysis of existing works and leads to what Laske calls "personal scripts." Although these scripts are mental constructs, I think it is clear that they are closely related to print and the compositional process associated with it, namely the deterministic specification of notational details. It is this model that I am referring to with the term "literate composer." In our comparison of the MIDI based pop composer with Koenig in their uses of the computer, it is clear that the former, despite the synthesized output, is composing with model-based scripts, while the latter is elaborating a rule-based approach, despite the eventual scoring for instruments.

Therefore, the shift away from composition as a literate activity will not necessarily mean the abandonment of notation, but rather a change in the traditional thinking that resulted in notation as its sole representation. The "post-literate" composer may bypass notation entirely by dealing directly with sound or will view notation as a convenient representation of the result of an algorithmic process. Scores probably won't disappear, but they may become just one of many forms of representation of music. Their symbology has expanded considerably during the 20th century, and it remains to be seen whether notation can keep pace with the expanding dimensions of musical thought. The desire for complexity is already leading many composers to the use of the computer to generate structures that do not seem to be possible to achieve by pure introspection or personal scripts based on past models. However, from the listener's point of view, I wonder if increased complexity involving only abstract relations between musical parameters conceived as independent variables will survive as meaningful communication and have an audience. Perhaps the current popularity of minimalism and neo-romantic music represents a desire for some respite from the excesses of abstract complexity.

Redefining Musical Complexity

Post-literate complexity may involve a serious re-evaluation of what musical complexity refers to, in what sense a leading edge music is complex. If my prediction about psychoacoustic variables becoming more inter-related through complex percepts proves true, then a similar development at the level of musical variables may have a surprising result – a return to melody. Melody occurs as an intricate relationship between pitch, rhythm and dynamics. Its subservience to harmony in the 19th century and its fragmentation in the 20th where its parameters were treated independently have caused us almost to forget how intricately entwined those parameters can be, moreso in melodic performance than in its notated form. Sundberg (1983) and others have illuminated the complexity of the performance rules required to translate notated melody into a musically satisfying aural result.

Similarly, complex rhythms found in world music are enjoying a renewed interest in the West. Their study reveals a complex link to movement in traditional cultures where music has a rhythmic vitality that starkly contrasts with the aridity of most modern, abstract approaches to the subject. There is also a renewed interest in myth, story-telling and ritual as inspiration for contemporary narrative and mixed media practice. A new complexity, then, may involve both a re-assessment of the sophistication of what literate culture regards as "simple" oral culture, as well as the exploration of new expressions of musical complexity. But perhaps even these new forms may find their inspiration and precedents in the complexity of the natural soundscape.

For me personally, the shift has already occurred in the sense that I have no interest in new music that is based on instrumental music concepts, whether performed by instruments, voice or computer. Such music, though perhaps complex to the composer, but more frequently derivative of earlier complexity, seems to me to have the same reduced dimensionality as the Fourier model compared to the complexity of real-world sounds. The clearest examples of the compositional paradigm shift are in musics based on timbre and space – a multi-dimensional environmental music by comparison to the flat pitch-time grid of conventional literate music, or what Trevor Wishart (1985) describes as "lattice music."

Thus, the paradigm shift can be described not as simply a return to orality, which is impossible, but rather as a neo-orality, or "secondary orality" as Ong (1982) terms it. It means a return to the sense of complexity which sound has in the acoustic world where all vibrations are unique to their time and space, unrepeatable in any exact sense, reflecting all aspects of source, medium, and spatial environment. It is a complexity which is information rich in the meanings extracted by the listener (Truax, 1984). It also means a return to the complexity found in oral culture where sound reflects a constantly changing present – a "becoming" – where repetition means re-enacting the structures of sound combined with other sense modalities, since sound cannot be exactly repeated as in the degenerate manner of contemporary media products.

The paradox is that I see technology as central to the new sense of music as complexity in that it provides tools such as the computer that superbly allow us to model and control complex systems. The paradox, however, is only apparent, since technology is an embodiment of our knowledge and our models of reality. If we choose to model linear, deterministic or literate systems, then the technology will reflect those models, and their limitations, back to us; if we choose to model complexity, it will lead us in that direction as well. However, we cannot always foresee the result of complex systems as we can with linear ones, and so the computer will become more of a partner in this exploration rather than our slave. As such it becomes an indispensable framework for extending our way of thinking about music and sound (Truax, 1986).

Healing the Rift of Music and Context

The final concept that will disappear with the demise of the literate composer is that of the abstract, context-free work of art. Throughout the history of communication, literacy has been closely entwined with abstract thought – ideas that appear to exist outside the self just as writing exists independent of uttered sounds. The result in our culture is the high place accorded to the abstract work of art, abstract both in the sense that it combines elements only in relation to each other, and also in the sense that it is performed or exhibited under standardized, generic conditions and is not rooted in a real context.

Although music in the real world may be written for specific occasions, ensembles or performers, these particularities do not enter the theory of music composition as relevant variables. In musicology, some so-called "radicals" such as Susan McClary (1987) have commented on the "blasphemy" that music (European classical in particular) should be discussed in terms of its social, cultural and political context. In teaching music we have perpetuated the ideology of the primacy of abstraction in that it quickly becomes clear to the student that abstract music is regarded as the highest form of art that only the chosen few can aspire to creating. Such art inhabits an imaginary world apart from the realities of everyday life, and more often than not those realities are only seen as frustrating practicalities that mar the idealized goal such music aspires to. Little wonder that the real world, having little need for such abstraction, provides small audiences and few jobs for the composers who graduate today from such training. Unfortunately, the spiritual and aesthetic needs of the real world, which seem to me to be as compelling as ever, also seem poorly answered by such abstract music, as if the lack of grounding in a real context correlates with its spiritual and emotional aridity.

The music of complexity I envision finds its basis in the unique contexts of the real world. These include its physical attributes (space and time, acoustics and environment), its social situations (specific individuals, institutions, and cultural heritages), and also its psychological realities (emotions, archetypes, imagery, metaphors, myths and symbols). The composition and performance of a music of complexity cannot exist without specific reference to some or all of these aspects of reality. In other words, it is not simply a matter of analyzing the music with reference to these terms; the music is *created* in response to them as well. Hence its complexity derives not only from internal relations, as in the Western classical tradition, but from its external relations as well. This simultaneous motion inwards and outwards provides a way of integrating sound and structure, the separation of which has been a hallmark of the instrumental music tradition (Truax, 1990c). In short, I foresee a point at which not only the rift between sound and structure is healed, where the two are inextricable, but also the division between music and context. Both art and environment have deteriorated with their separation, and a reunion cannot come too soon.

What becomes a new music of complexity will depend on the creativity of those entering the 21st century. Many of those people are now students and therefore the examples we set, and the teaching and research we do are of great importance. However, trying to pinpoint specific current styles that presage a new paradigm, such as Attali (1985) attempts in his chapter on "Composing," is probably too narrow and subjective. Utopian and anti-utopian visions usually say more about the times in which they were written, as well as the optimistic or pessimistic character of their authors. Instead of predictions about such future music, I would rather emphasize the nature of the process that I hope will produce it.

I have already identified the sites and levels of reference of the process – the physical, social and psychological attributes of the real world which provide a complex context that informs the work of the artist. Technology will likely be involved, though not necessarily since its processes can carry over into purely acoustic practices. However, the unique opportunities that technology provides to design sounds and the process of their organization will likely stimulate the imagination for years to come. Moreover, the technical possibilities of diffusing sound in real spaces and within media environments offer endless sites of activity. Social and cultural contexts also need to be brought into the compositional process, and the inner world of the psyche will always find its expression through the composer who bypasses the limitations of words with sounds.

Through an intense involvement with context, however, the composer's work may cease to be exclusively artistic and may start to involve practical educational, social and environmental uses. Perhaps a new designation such as "sonic designer" will become more appropriate. In stark contrast to the endless laments about too few jobs for the composer and not enough audiences or support for new music, there exists a multitude of needs involving sound waiting to be filled. Our reverence for the abstract and the narrow training that goes with it prevents us from addressing these needs, but they are there and crying for artistic sensibility to be applied. If we reject these options because we think that such practical involvements are "second class" in comparison to "high art", then we have nobody to blame for our isolation on the periphery except ourselves. However, with the field of activity widened and guided by a new worldview, we may yet make the world of sonic experience a vital force in society once again.

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Barry Truax, born in Ontario in 1947, is Director of the Sonic Research Studio and Associate Professor in both the Department of Communication and the Centre for the Arts at Simon Fraser University where he teaches courses in acoustic communication and electroacoustic music. His training has been both in the sciences, at Queen's University, Kingston, and in music, at the University of British Columbia. He has also studied at the Institute of Sonology, Utrecht, with Koenig and Laske. In 1973 he came to S.F.U. to work with R.M. Schafer and the World Soundscape Project, through which he has pursued an active interest in environmental sound. Since 1972 he has been developing and using the POD computer music system for composition and sound synthesis, and it, along with classical and electronic techniques, has provided the material for most of his compositions. These roughly divide into works for tape solo, and works which combine tape with live performers.

His works have often been performed at festivals in Europe, computer music conferences, and on new music concerts and broadcasts in Europe, North America, Australia and New Zealand. In 1977, his *Sonic Landscape No. 3* won first prize in the computer music category of the 5th International Competition of Electroacoustic Music in Bourges, and in 1980, *Arras* received honourable mention. He has published numerous articles on computer music and soundscape studies, and is co-author of *Five Village Soundscapes* and editor of the *Handbook for Acoustic Ecology* in the Music of the Environment series of World Soundscape documents. A recent book *Acoustic Communication* has been published by Ablex Publishing, Norwood, N.J. In 1985 he was Conference Director of the International Computer Music Conference held in Vancouver where his record *Sequence of Earlier Heaven* was launched on the Cambridge Street Records label which he has founded. Five of his works appear on the Compact Disk *Digital Soundscapes*, published on both the CSR and Wergo labels.