Free music and the discipline of sound

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The history of music in the twentieth century is viewed as a process of expanding the sonic material of music to include all sound. Technological barriers to the full exploitation of the domain of sound are suggested as causing the process to take more time than it would otherwise due to cultural or aesthetic factors alone. Important historical developments in music over the last century are reconsidered to be, at least in part, strategies for circumventing technological limitations to manipulating and accessing all sound. Support for this perspective is found in the words of artists and composers of the time and in comparisons between the technologies available for creation in the visual and the sonic arts. Sound modelling is examined as a post all-sound paradigm holding promise for normalising the relationship between sound and music.

1. INTRODUCTION

Music in the twentieth century went through a remarkable period of expansion beyond its traditional boundaries. The concept of tonality as the fundamental structural element was brought into question with timbre receiving growing interest in its stead. Com posers employed serial techniques to systematically purge any remnant of tonal structure. Indeterminacy, ambient creations, sound sculptures and installations have pushed other limits in our understanding of the relationship of music to images, the environment and the audience. If musical forces of change were not enough, new technologies enabled the introduction of electronic instruments with capabilities previously impossible – initially by extending the pitch range and making a pitch continuum available. Recording and broadcast technologies (wire, tape, phonographs) enabled vast distances in time and space between the production and the consumption of music. Recording technologies also created the possibility for sounds to be heard twice exactly the same way, and the ability for composers to create music 'directly' without performers as intermediaries.

The most fundamental change of all, however, has to be the introduction of 'all sound' as the material for making music. After all, music will always be of sound, whether tonal or not, recorded or performed live, composed serially, stochastically or automatically, whether tied to other media and modes of perception, or 'absolute' and autoreferential, whether created directly to a recording media or notated for interpretation by performers. The expansion of the sonic domain for music breathes new life into all these ways of composing, performing and listening, whether traditional or innovative.

For all of the articulated visions of sound in music, for all of the experiments and new sonic works of art that have been produced over an entire century, still today the vast majority of musical output is tonally structured, while much of the pioneering work of twentieth-century composers is largely marginalised. Except in a few special cases, free 'all-sound' music hardly touches the popular psyche, the concert halls, film, computer games and mass media uses of music, and there are few amateur practitioners. The central question addressed herein is, given a century of opportunity, why is it that free music still lives so far from the mainstream? Even within the halls of the modern academy where music has long since broken traditional bounds in principle, much of the music composed today is still note-based and harmonically structured. Those who insist that pitch and harmonically structured music will one day be considered but a foot-note upon which stands a more richly sourced music, must explain why it is taking so long for sonically unrestricted music to establish itself.

Among the musical, cultural, social, and even biological factors that may enter into an explanation of the continuing dominance of tonally structured music, we suggest that a primary cause of this state of affairs is that our mastery of sound morphology and, in particular, our current technology of sound creation, transformation and control, are as yet not up to the task of supporting the all-sound ideal for music. There is a significant technological hurdle that has obstructed composers from freely availing themselves of arbitrary sounds and sound transformations in the all-sound world. The sonic world has yet to be mastered, and there is much that we, as scientists, software engineers, instrument designers and composers, neither understand nor yet know how to do with 'all sound'.

We will take a somewhat revisionist look at some of the important musical developments of the last

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century as a history of sound making its way in fits and starts into the realm of music. If we were to first take a step into a future in which all sonic material and transformations are equally accessible, and then look back at the first century of the process of incorporating sound into music, things would look a little different than they do to us now before the access to sound has been homogenised. The percussion music of the 1930s and 1940s, experiments in performance indeterminacy, Cage's prepared piano and Schaeffer's 'reduced' listening strategy, can all be viewed as different intermediate approaches to including new sounds in music before more powerful technologies for doing so were available.

To view works of art in terms of technologies that were not available at the time they were created may seem odd, somewhat unfair, overly revisionist, or irrelevant to the understanding of individual pieces. A more usual 'history of art and technology' approach would look at the flowering of styles of art that have been engendered by inventions such as the phonograph, electricity, or long-distance communication. Furthermore, the last century saw a tremendous exploration of new concepts in music that are variously independent from the musicalisation of sound in areas such as performance practices, notation, spatialisation and sound diffusion, serialism, non-determinism, movements purging emotional 'evocative' and symbolic tricks, experiments in process versus musical product, explorations in super/subsonic material, control via brainwaves, radio signals from space, and composer/performer/audience relationships. However, focusing on the influence of a technology gap on the musicalisation of all sound is justifiable given the coherence of explanation the approach lends to many historical developments. The words of composers themselves in their manifestos and other documents explicitly lament the gap between their visions for music and their ability to implement them. A comparison of technologies for sound and music with those for graphical arts will also justify the consideration of a technology gap in the story of twentieth-century music-making.

A brief note on terminology – *a sound* is a dynamic thing. This is true trivially at short time scales (sound is air pressure changes in time), and generally so at long time scales since 'sounds change'. 'A sound' can refer to a brief sine tone, a series of footsteps, or a two-minute continuous evolutionary 'morph' from a held trombone note to the crackling of a campfire. Indeed, this seemingly barely-worth-mentioning fact is at the heart of what makes the space of sounds so huge and such a technological challenge to discipline.

2. EARLY VISIONARIES

It has been roughly a century since the early expressions of the idea that all sound could potentially be used for musical purposes. Previous to that time, there was a general understanding that some sounds were musical, others intrinsically not, except perhaps as 'special effects'.

There has been a wonderful history of written documents calling for the expansion of the sonic domain of music beyond the classical notions of tonality. Ferruccio Busoni is perhaps the most often cited of the visionaries. In his *Sketch of a New Esthetic of Music* (Busoni 1906/1911) he describes his experiments to go beyond the confines of traditional tonal structures. He disparages the music 'lawgivers' declaring, 'Music is born free; and to win freedom is its destiny', though his ideas were far more manifest in the music of his students than in his own. Visions of a widening sonic domain were floating around among many musicians, poets and artists during the first decades of the twentieth century, and found an early expression in a Russian publication of 1910, *Studiia Impressionistov*, organised by the painter/poet/philosopher Nikolai Kulbin in an article entitled 'Svobodnaya Musica' ('Free music'), in which he writes:

> People are organs of a living earth – and the cells of its body. The symphony of the cosmic concert is the music of nature – the natural 'free music'. If you pay attention to this art and laws of its development, everybody knows that the noises of the sea, wind, thunderstorm, makes a symphony as well as the music of birds – but right now, people exploit the music of nature according to the old laws – if they were paying more attention, they would be enlightened more – It would turn out that water, air and birds, don't sing according to our notes, but using all the notes that they find pleasure in – and with that, the laws of the natural music are observed exactly. (Kulbin 1910; translated from the Russian by Ruslana Zitserman and the author)

The present article takes its title from the writings of Busoni and Kulbin and later Grainger, with their use of the term 'free' to describe music breaking traditional tonality barriers. 'Free music' is perhaps less awkward than 'all-sound music' and does not have the negative characterisation of 'non-note' music. The otherwise descriptive term 'sound art' has generally come to mean something beyond the 'mere' expansion of music into the domain of all-sound, to include other non-sound media such as sculpture, installations, and new ways that audiences typically interact with a piece (Kahn 1992: 1). The common term 'electroacoustic' casts a wide net, but is commonly understood as restricted to loudspeaker-mediated presentation. Even within those confines, the term may permit, but is not explicit in its openness to all-sound for which we want a new term. The term *free music* will be used to simply mean music that is not *in principle* restricted in the domain of sound from where it draws its source material.

3. A LOOK BACK OVER THE HISTORY OF SOUND IN MUSIC

Three important phases can be recognised in the unfinished historical process of the musicalisation of sound:

(1) every sound is admissible,
(2) every sound is theoretically realisable,
(3) every sound is in practice equally accessible.

3.1. Every sound is admissible

The idea of sound in music arose during politically, socially and technologically tumultuous times. Many disciplines were breaking traditional bounds. Painters moved away from representation toward the impressionistic and abstract while photography laid its claim to realistic image depiction. Sound poets went beyond words to explore ways in which their voices could be used in new forms of expression, and the futurist movement produced practitioners and advocates of these new approaches across all disciplines, not the least of which was bringing noise into music. The industrial revolution of the preceding century and the resulting new city soundscapes dominated by factories, construction, machines and engines, not to mention the horrific sounds on the battlefields of World War I, provided inspiration for many to explore the artistic use of noise (while perhaps putting others off from the idea).

Busoni had quite a few students who played an important role in welcoming all-sound into music, among them the colourful Futurist painter and musician, Luigi Russolo. His 'Art of Noises' manifesto, published in 1913, much more than a vague expression of an intuition, discusses the *intonarumori*, or noise instruments, he was building for the new music. Though his inspiration came largely from sounds of the post industrial revolution city, his idea was specifically that the sounds they produced could be used in a formal musical way, not merely as simple sonic imitations of worldly objects. He said, 'It will not be through a succession of noises imitative of life but through a fantastic association of the different timbres and rhythms that the new orchestra will obtain the most complex and novel emotions of sound' (Russolo 1913). Marinetti also underscored the non-imitative aspect of the instruments when he said at his home before the first noise-music performance, 'By a knowledgeable variation of the whole, the noises lose their episodic, accidental, and imitative character to achieve the abstract elements of art' (Brown 1986).

After the idea of 'noise' in music had entered the artistic milieu of the early twentieth century, the next step was to gain its acceptance by the audiences of the day. This was to prove a difficult task, and in the 1910s and 1920s, musical premiers were occasions at which audiences regularly made their resistance to unfamiliar music known in colourful and dramatic ways. Russolo reports police intervention to stop riots at his concerts (Russolo 1916: 34), but sounds did not have to be as radical as those made by Russolo's noise instruments to ignite an audience. The premier of Stravinsky's *Rite of Spring* in May of 1913 provoked derisive laughter in the first few bars leading to noisy disruption throughout the piece (Stravinsky 1936). In 1923 the premier of Varèse's *Hyperprism* with the use of rattles, an anvil, Indian drums and Chinese blocks caused a walk out of half the New York audience. The premier of George Antheil's *Mechanisms* that same year in Paris resulted in fighting and total pandemonium (Antheil 1945: 132).

Progress in audience acceptance of new sounds and music was not smooth and continuous. By the end of the 1920s, the *New York Times* was hailing Stravinsky's *Rite* as the twentieth century equivalent of Beethoven's Ninth (Gutman 2001), but as late as 1954, even *Deserts*, composed by the then established and venerable Edgar Varèse at Schaeffer's studio and performed on a concert in Paris flanked by works of Mozart and Tchaikovsky, created an uproar in the audience. If such a reaction could still be provoked in the 1950s, then it seems less surprising that Russolo's much bolder use of noises thirty years earlier could have caused such a public commotion.

One of the difficulties for the acceptance of all sound into music has to do with the natural tendency of sounds to invoke 'extra musical' images of their sources and causes. Indeed, Kahn (1990, 1999) faults sound composers like Russolo, Schaeffer, Cage and Varèse for a process of musicalisation that systematically purged sounds of their natural signifying role. The art of sound effects exploits the referential quality of sounds, but has an entirely different status and set of practitioners from music, even though the craft scaled new heights with ingenious inventions for creating illusions in theatre, film and radio (Mott 1990). As hard as Russolo worked to design his instruments explicitly for making sounds that could be heard independent from references to a familiar source, the 'brutist' instruments were criticised by another all-sound innovator, Edgar Varèse, for imitation: 'Why, Italian Futurists, did you slavishly reproduce all the agitation of life in the form of noise, which is merely life's most superficial and bothersome element?' (Varèse 1917). The painter Piet Mondrian, concerned with moving away from physical depiction in his own work, similarly criticises the Futurists' music (Mondrian 1921) for failing to attain the 'abstract plastic'.

Noises seemed to clash with music when they were put together, and on the other hand, they were seemingly unable to stand alone as a new art form. We might forgive an audience for its 'close mindedness' when presented with these early musical experiments given such limited capabilities of sound generation that were in the hands of composers. Art consumers of the early twentieth century were in fact accepting quite a bit of change across the spectrum. It is illustrative to compare the development of painting at the time to that of music regarding literal reference.

As painters and artists pushed ahead with surrealism, impressionism, and abstract expressionism, artists such as Kandinsky and Mondrian held music in high esteem for its very detachment from worldly referents, and music inspired their own moves in that direction. However, to varying degrees, paintings usually still had discernible links to real-world objects, if only obvious in the titles of the works. Certainly, audiences had some difficulties with new non-representational styles, but they seem mild compared with the reactions described above to new music, and simple cultural hysteresis seems sufficient to explain the modest resistance. In general, acceptance came quickly. Prior to 1910, for example, Braque and Picasso had collectors and were commanding respectable prices for their earliest cubist experiments that merged non-representational dimensions with depiction (Mailer 1995: 295). Painting could be both 'of' real-world objects, and at the same time incorporate non-realistic elements and styles. Music, however, was considered that much less the art for incorporating anything other than the purely abstract.

Among the many possible explanations there might be for the asymmetry in the acceptance of real-world signifiers in painting and music, one that seems too rarely considered is that painters did not have the same technological hurdles to overcome as composers in realising their new forms. Composers had only the crudest control over the sounds they were using, and were not able to realise the subtle nuance necessary to, for example, make a foghorn sound as if it were playing in a thick fog across windswept waters. Armed with skill and the standard tools of their trade, a painter's vision was realisable. There was infinite room for different, but closely related styles. Within the domain of painting, all colours, lines, textures and patterns were technologically equally accessible. There were no legions of painters bemoaning the lack of tools to realise their visions or calling for engineers to assist them in doing so.

For composers of sound, things were different. Varèse expressed his vision (and frustration) early in the story of sound and music: 'I dream of instruments obedient to my thought and which with their contribution of a whole new world of unsuspected sounds, which will lend themselves to the exigencies of my inner rhythm' (Varèse 1917). In 1922, Varèse voices what would become a life-long refrain, that the way in which the gap between musical vision and realisation will be closed is that 'the composer and the electrician will have to labour together' (Chou 1971).

In the 1930s, the all-sound visions were still pouring forth. Grainger wrote an essay with echoes of his teacher Busoni, entitled 'Free music' (Grainger 1938/1996). It lamented music 'tied down by a set of scales, a tyrannical (whether metrical or irregular) rhythmic pulse that holds the whole tonal fabric in a vice-like grasp and a set of harmonic procedures (whether key-bound or atonal) that are merely habits, and certainly do not deserve to be called laws'. He also appealed to the sounds of nature, where '"free" (non-harmonic) combinations of tones' are heard, and he invented a number of instruments from materials including vacuum cleaners, pneumatics and reeds, sewing machines and a hand drill, which he called 'free music machines' (Kahn 1996).

Grainger, with his interest in irregular rhythms, gliding and inharmonic tones and new instruments, took only baby steps toward admitting sound compared with the radical simplicity of John Cage, who in the 1937 essay, 'The Future of Music: Credo' (Cage 1961), suggested substituting Varèse's term 'organised sound' for music. Referring to noise (e.g. a truck, static, rain), he says, 'We want to capture and control these sounds, to use them not as sound effects, but as musical instruments', and speaks of electronic instruments 'which will make available for musical purposes any and all sounds that can be heard'.

Although the notion 'capture and control' would later be entirely expunged from Cage's approach to music, the acceptance of all-sound is clear. The possibility of reaching his all-sound goals is, however, still spoken of in the future tense. With the acceptance, but inability to control the entire domain of sound, many composers in the 1930s and 1940s instead explored rhythm and the sounds of percussion instruments.

Percussion was the way toward all-sound taken by Cowell (extended piano techniques of *Aeolian Harp* and *Banshee* in the early 1920s, the Rhythmicon invention of the 1930s), Varèse (*Ionization* in 1931) and Cage with his percussion orchestra. This was also a time of a flowering interest in rhythms and sounds from outside European and American traditions, such as the islands of Bali and Java in Indonesia, South America and Cuba, led largely by Cowell and including Lou Harrison, William Russell and others (Cowell 1940). Harrison and Cage were together producing percussion and dance concerts with instruments outside the bounds of traditional percussion instruments such as Harrison's *Canticle*, employing flowerpots, water gongs, brake drums, sheets of metal and utility pipes. Cage's rhythmically oriented pieces of the 1930s and 1940s were also part of an exploration of duration (as opposed to harmony) as fundamental structural element in music, the one 'determinant' of sound that is common to both sound and silence (Cage 1949/1961: 63). Rhythmic structure, he said, could embrace any sounds of any qualities and pitches, including silence.

Cage also extended the percussion sounds of the piano with his first 'prepared piano' piece, *Bacchanale*, in 1939. Schaeffer, in his (1950) 'Vers une musique experimentale', appreciates this 'transitional' instrument, 'the prepared piano helped us through some difficult moments, providing transitional works to appease the public, the administration and ourselves' (Palombini 1998).

The explosive interest in rhythm and percussion was a natural step in the long process of admitting sound into music, and one that composers could avail themselves of with the technology of the day. Also in the 1937 'Credo', Cage calls percussion music a transition from keyboard-influenced music to the all-sound music of the future, and in an interview following a performance of Lou Harrison's *Canticle* in 1942, he said that he considered percussion music not an 'end in itself, but we are trying to make all the field of audible sound available for music' (James 1942).

3.2. Every sound is possible

Over the course of the twentieth century, new technologies continued to expand the range and control of sound that was available to musicians, reaching a point where any sound came within the realm of theoretical possibility. Theoretical possibility was still to prove inadequate for the realisation of musical vision. Some technologies that now seem like obvious tools to put to musical purposes were not exploited as early or as fully as they might have been due to social and economic realities (Chavez 1937: 119, 134). When the synthesis and recording technologies did make it into the hands of artists, sound manipulation technologies still enforced a certain conformity of musical expression. Underscoring the contemporary sense of technological limitations to all sound exploitation is that aleatoric methods were developed partly as an explicit strategy for circumventing them.

Although audio recording technology had been invented before the turn of the twentieth century, and used as early as 1908 in Carol-Bérard's *Synphonie des Forces Mécaniques* for sounds of motors, electric bells, whistles and sirens, it was not until the 1920s and 1930s that the technology was exploited by the likes of Milhaud, Hindemeth and Ernest Toch for its sound manipulation capabilities such as changing speed and playing sounds backwards (Stuckenschmidt 1969: 176). Live use of such electronic manipulation of recorded material did not appear until Cage's 1939 *Imaginary Landscape No. 1* included performers manipulating the speed of turntables.

Electronic musical instruments also have a long history, but with regards to all-sound, the early instruments and tools were better for fuelling the imagination than for introducing new possibilities into musical organisation. Many of these instruments invented over the course of the first half of the twentieth century (Telharmonium or 'Dynamophone', Theremin, Ondes-Martenot, and Grainger's 'Free Music' machine) filled in the pitch continuum and extended the pitch range of traditional instruments while providing expanded, but still limited capacity for timbral expression. As expressed by Pierre Schaeffer in 1957, 'Instead of destroying notes, the last stronghold of traditional music, they put in some more' (Palombini 1998).

A new era was heralded in 1951 with the founding of the electronic music studio in Cologne which included tone generators and a Bode Melochord (Bode 1984) with filters and envelope shaping capabilities, together with the founding that same year of Schaeffer's radio studio at the *Radiodiffusion-Télévision Française* in Paris with its tape-based sound manipulating equipment such as the keyboard *phonogène* (Palombini 1999). The combination of the ability to construct timbres with elementary components and filters, and the ability to record and manipulate sounds suggested that finally any sound was not just acceptable, but realisable. Schaeffer began the systematic search for a method and criteria for classifying the infinity of sonic material newly available. 'How to imagine a priori the thousand unpredictable transformations of the concrete sound, how to choose from among a hundred samples, if neither a classification nor a notation has yet been defined?' (Palombini 1998).

Schaeffer is well known for his concern over the tendency for people to hear the sources of sounds rather than the formal relationships he was interested in. He suggested a method of *ècoute rèduite* (reduced listening), which requires the wilful effort to ignore the events and objects 'behind the curtain' and focus on the sounds *per se* in order to hear their musical potential (Schaeffer 1967: 65). He may have had an easier time directing the attention of his audience away from the rich imagery of his source material if his technical powers of sonic transformation had not been limited to splicing, layering and time altering the complexity of the recorded sounds.

The German school struck off in other compositional directions. Interest lay in writing music free of 'non-musical associations' (Boehmer [n.d.]), and serial techniques were one important method of achieving the ideal. It may be a stretch to suggest that the serial techniques that the Cologne school promoted were another way to deal with the limitations of the technology in order to forge ahead with music-making. Boulez in particular was more concerned with developing musical form than in sound *per se*, and viewed the new sonic capabilities as serving that end (Palombini 1998). However, given their entirely new set of sound-making apparatus and capabilities, the serial techniques were certainly no longer serving their original function of systematically deconstructing, or at least avoiding, tonal structure. Despite their near-religious proclamations about serialism finding its true home in the new electronic instruments, in fact, the elementary nature of the sound material they were working with makes it challenging to find non-note-based elements intrinsic to the sounds themselves from which structure could be built. Schaeffer on the other hand, despite the pesky distractions of sound source images, used a considerably richer palette of sonic material in his attempts to build structure from intrinsic sound characteristics.

Although the differences in sound sources and compositional style between the German and French schools in the early 1950s have generated much attention and hyperbole, many of the techniques of the two schools were similar due in large part to the underlying common recording technology. Herbert Eimert, composer and founding director of the Cologne Studio, was dedicated to elevating serial traditions. Even so, he listed twelve techniques that the concrete and the electronic schools of composition had in common, including sound superposition, exact repetition, speed changes, retrograde forms, and spatialisation via multiple speakers (Stuckenschmidt 1969: 177). The vastly different aesthetics of the two schools had a technological bottleneck in common.

In fact, the German school was also subject to uncontrollable real-world references. In the opinion of the contemporary historian and music critic H. H. Stuckenschmidt, 'The unbriefed listener encountering a work by Schaeffer, Henry, Eimert, Beyer or Stockhausen for the first time would take much the same impressions away with him. Far more than any traditional form of music, the pieces evoked associations that the composers had in no way intended. Purely subjective mental pictures suggested themselves: many of the sounds had the effect of auditory spirals or crystals, others were reminiscent of gurgles, air bubbles, giant drops of water and the like' (Stuckenschmidt 1969: 184). Independent of whether a given composer from Stuckenschmidt's list was attempting to write absolute music or not, the perception was that the imagery was 'in no way intended'. The lack of intentional control over musical affect, together with the fact that compositions emanating from such a wide range of compositional aesthetics all produced the 'same impressions', implicate the common rudimentary sound manipulation technologies as an obstacle to achieving free individualistic musical vision.

John Cage took a different approach to making music with all sounds without waiting for twenty-first century means of synthesis and control – indeterminacy: 'I would assume that relations would exist between sounds as they would exist between people and that these relationships are more complex than any I would be able to prescribe. So by simply dropping that responsibility of making relationships I don't lose the relationship. I keep the situation in what you might call a natural complexity that can be observed in one way or another' (Nyman 1974: 29). The fact that indeterminacy is described as a method for achieving something he could not achieve otherwise, suggests that the explorations of chance that so dominated musical development in the middle of the last century grew not only out of an aesthetic sensibility, but also out of a need to deal with the technical problems of bringing sound into music. Indeed, a half-century later when complexity is considerably more prescribable, we also find that indeterminacy plays a smaller role in compositional form.

Xenakis also undertook a systematic exploration of aleatoric means to composition and sound synthesis using, for example, 'clouds and points and their distributions over a pressure–time plane . . . (to) . . . create sounds that have never before existed' (Xenakis 1990: vii). Even the electronic synthesizers integrating huge numbers of electronic components still left the 'all sounds are possible' claim with a hollow ring. Xenakis wrote in 1971 about the 'obvious failure, since the birth of oscillating circuits in electronics, to reconstitute any sound, even the simple sounds of some orchestral instruments' (Xenakis 1990: 243–4). At that time he identified the failure as due in part to (i) a lack of subtle variations, (ii) a lack of complexity such as noisy sonorities and complex transients, and (iii) an inadequate understanding of psychoacoustics.

The introduction of the computer as a musical tool provided what seemed like the final justification for declaring that all sounds were possible. Max Mathews, then working at the giant telephone company AT&T said, '. . . generating sounds from numbers is a completely general way to synthesise sound because the bandwidth and dynamic range of hearing are bounded and therefore any sound we perceive may be generated in this way' (Mathews 1963). Of course strings of numbers are not the whole story, and Mathews is a bit more reserved when he writes, six years later, 'The two fundamental problems in sound synthesis are (1) the vast amount of data needed to specify a pressure function – hence the necessity of a very fast program – and (2) the need for a simple and powerful language in which to describe a complex sequence of sounds' (Mathews 1969). The Xenakis (1971) critique of electronic music implicated computer-controlled synthesis as well for its lack of subtlety and complexity.

3.3. Every sound is equally accessible

Theoretical access and equal access to all sound are fundamentally different in a musical context. Given the circumscribed domain of traditional tonal music, there are no melodies or harmonies that are more accessible than any others to the composer. A similar 'equal access' to their respective sonic material is not available for free music composers. Despite the theoretical access to any sound that the computer provides, in practice, access is yet nowhere near uniform. Given that computers are orders of magnitude more powerful than when Max Mathews extolled the complete generality of digital synthesis in 1963, what does it mean to say that all sounds are not yet equally accessible?

Consider the following analogy between the limitations facing a free music composer with a hypothetical situation for a composer of traditional instruments and harmonic traditions. Imagine that each orchestral instrument were split into one hundred almost identical instruments, each one being able to play but a single note of the range possible on the original instrument. To play a piece of music, the orchestra of restricted instruments would involve one hundred times as many players. A legato bassoon melody would be theoretically possible, but in practice extremely difficult to achieve. To make the analogy more accurate, imagine that some of the single note instruments are missing so that, if needed, they would have to be faked by a combination of other instruments or played from a recording. The economic, physical and time constraints of this instrumental situation would certainly have made the composition and performance of most of our venerable classical orchestral repertoire a practical impossibility despite the theoretical possibility of producing them. Such is the state we find ourselves in with computers as sound machines at the beginning of the twenty-first century. A state-of-the-art computer music system puts some clearly defined classes of sounds and transformations at the fingertips of the composer, while certain other sounds and transformations require an entirely disproportionate effort to achieve. Equal accessibility for the sounds of free music would mean that the available tools do not strongly bias a composer towards one kind of sound construction over another, just as any melody and harmonic structure is equally accessible to the traditional composer.

As we enter the twenty-first century, composers (who are often software engineers as well) find that they must frequently invent and develop new tools to attain their compositional goals. For many composers, this is itself a musically rewarding process and does produce wonderful musical experiences for audiences, but not all composers have the technical skills to do this. Because of the limitations of available synthesis techniques on commercial synthesizers and computers, these devices 'easily impose their own spectromorphological character and clichés on the music' (Smalley 1997). One frequent complaint of audiences following a performance of a contemporary electroacoustic work is that a synthesis technique has drawn attention to itself at the expense of the music. When technology reaches a greater maturity with respect to music, the decisions made during composition, exploration and experimentation will be of sound itself, and be enabled rather than restricted or defined by the tools. Of course, composers have always had to master a plethora of technical skills (e.g. playing instruments and orchestration), but software engineering need not always be one of the requirements for a composer with proper musical tools for working with sound.

There are many ways in which contemporary composers manage the problems that arise from the lack of tools for exploiting the entire sonic domain. Many who are well past the stage of acceptance of all sound as valid material for music, nevertheless turn back to traditional tonally structured music in their work. If composers wish to write in a way that they can direct and predict the listener's response to their compositional decisions, it is still easier to use the widely shared conceptual and technical tools already in place for exploiting tonality to build musical structure.

Presenting music *acousmatically* (without providing visual access to the sources of sounds) helps solve several problems. If there are technical impracticalities of real-time synthesis, pieces can be realised in the studio and presented from a recording over loudspeakers. Even when real-time synthesis is achievable, the acousmatic presentation can help circumvent distractions that can arise from a legacy of traditional modes of listening in which audiences are accustomed to a specific one-to-one relationship between sound and performance gesture. Acousmatic presentation thus facilitates either a Schaefferian *ecoute reduite* (discussed above), where the focus is intended to be on the morphological qualities of sounds rather than on the source object or action, or a mode of listening where sound sources different from those actually responsible for the creation of particular sounds are invoked (Windsor 1995).

Lacking the ability to easily create certain classes of sounds, the flexibility of synthesis can be sacrificed and the desired sound simply recorded (if it can be found). Compositions in the *soundscape* genre are commonly constructed of sounds recorded from particular places and times. Soundscapes occupy a continuum from realistic and essentially unprocessed recorded material to transformed sounds with only a tenuous perceptible connection to its original source. However, purely synthetic sources are rare since, according to Barry Truax, one of the pioneers of the genre, 'no synthesis methods have been devised which can produce realistic environmental sounds (as distinct from speech and musical instrument synthesis which have received more attention)' (Truax 2002). Truax finds hope particularly in granular and wavelet analysis, synthesis and transformational techniques to enable integration of the synthetic and natural, and to precisely control soundscape environments.

4. GOING FORWARD: SOUND MODELS

What is the way forward that will give artists the access to the sounds they have been envisioning, that will allow free music based on an unlimited sonic palette to permeate the musical milieu, and that will offer the appropriate tools to enable amateur music-making to be part of anyone's everyday life? If the answer lies in technology, it is not with simply ever-faster computers, but rather with tools that provide new ways of working with and accessing sound by composers, audiences and performers.

Kahn (1990) sees the digital audio recording workstation as an important step forward in providing an environment facilitating a fundamentally all-sound orientation of making music. The graphic and spatial interface to cutting, pasting and copying sound at any time scale, enforces 'no restriction to duration that mandates sequencing, no necessary adherence to any form of interval'. Partly because of the film and video design criteria, workstations are capable of manipulating sounds to simulate 'signifiers', thus permitting the reintroduction into sound art of its natural referential aspects that have been so systematically shunned by much of the twentieth-century musicalisation of sound.

Kahn also sees the limitation of the musical 'word processing' workstations in the primary dependence on recorded sources as elemental sonic material, and projects that 'next generation technology will break free of such accumulation through analysis and resynthesis; eventually sophistication will be gauged by the minuteness of the samples needed to elicit a simulation of potentially infinite articulation'.

Kahn's words foreshadow the musical importance of the concept of the *sound model*. A sound model is a computational object capable of navigating over a constrained range of sounds, under the control of a small number of parameters. Models exist between the rigidity of recorded material, and the generality of the ideal synthesizer. A model might use recorded source material, but we 'gauge the sophistication', or the extent to which it attains the nature of a model, by the minuteness of the samples needed. Models are not universal synthesis engines; they have a specific identity that comes from both their capabilities and their constraints in three independent dimensions: the range of possible sounds, the possibilities for traversing the range of sounds, and the parameters available for controlling their behaviour. Two models are distinct, for example, if they enable different paths through the same range of sounds. A 'footsteps' generator is an example of a sound model that would create an almost periodic series of events, each slightly different, and be parameterised by speed and surface characteristics.

Synthesizers are generally not good models, and Wishart casts the limitations of synthesizers in terms of modelling: 'Largely because instrument-definitions on such synthesizers are based on sound-objects and not on sound-models, then no matter how we transform the sound-material, we tend to perceive it as coming from a synthesizer . . . (there is a) lack of structuring in relation to perceptual sound-models' (Wishart 1996).

Synthesizers are built from elements much like those used by the electronic music of the 1950s and are largely focused on the signal processing level. Synthesizers expose parameters for the signal-level elements such as oscillators and filters, and the often massive number of parameters are the same for each and every sound the synthesizer produces. The signal processing and synthesis levels for sound are what colour, lines and polygons are to graphics. Sound modelling, however, at a level of abstraction analogous to graphical modelling, has received surprisingly scant attention. Until a rich set of tools exists for working at the modelling level, sound artists will not achieve the ease and range of expression now available to graphical artists.

Although signal-level synthesis plays an important role in any sound model, there is also a layer of control, constraints and behaviour implemented 'under the hood', relationships between low-level synthesis parameters and internal dynamics. A car engine, for example, involves multiple sound sources related by different kinds of mechanical and acoustic couplings producing a wide variety of noises under simple real-time parametric control (a gas pedal and engine 'work load'). Despite the internal complexity, we can clearly hear an underlying model identity, for instance that an engine does not change size, even though a wide range of sounds are produced over the control parameter range. Invariant structures defining behaviour are unique to each model, not generic. They are customisable by a single set of parameters, and they define morphological relationships between different sounds. Wishart (1983/1996) relates the sound model to his notion of 'intrinsic morphology' to help distinguish the model organising principles that exist over a class of sounds from the level of an individual sound instance.

The case for viewing sound modelling as a neglected technology becomes more compelling considering the attention and value attributed to modelling in the graphics industry. There are a myriad of graphics conferences and many hundreds of research papers presented each year devoted to specific problems in modelling hair, fire, textile folding, buckling and wrinkling, water, skin texture, or grass. Analogous attention to individual natural sounds is almost nonexistent (though the situation is beginning to improve). In describing his craft, a game sound designer recently wrote matter-of-factly, 'Whereas graphics can be created from the eye, mind, and hand of an artist, sounds must be captured' (Hill 2002). Games are an obvious place where sounds need to be interactive in real time and not limited by a set of pre-recorded material, but even in animations where the final project is delivered on a 'fixed medium', the production environment for creating and controlling sounds still needs to be as flexible as possible.

Where there have been concerted sound modelling efforts, it has mostly been directed at traditional musical instruments. Physical modelling using waveguide techniques (Karplus and Strong 1983, Smith 2000) are perhaps the most interesting in terms of representation and possibilities for extension. Physical models can provide very intuitive parameters (string tension or thickness, tube bore, etc.) and can also be parameterised to describe 'impossible' physical configurations such as, for example, a drum membrane with a 'vibrato' in thickness.

The 'source filter' architecture (Fant 1960) in speech synthesis qualifies as a model-based approach, providing low-dimensional control and internal behavioural constraints. Unfortunately, it is not particularly good at capturing the behaviour and sounds of human speech. The dominant commercial technique today achieves a high-quality sound using concatenation of very short pre-recorded speech segments, and as such cannot be considered a model – to significantly change or make the voice sound like a different person than the one originally recorded, another whole database must be recorded, cut and labelled. 'Articulatory synthesis' is a technique that incorporates explicit physical models of airflow dynamics and the human vocal apparatus. It is a strong model with a small number of intuitive parameters, and has the potential to represent different voices based on different parameter constraints.

Despite the complexity of modelling speech and musical instruments, these sounds account for small and special domains of the sonic world as a whole. Footsteps, engines, birds, animals and splashing rain are but a few categories of natural sound sources that each have their own set of behavioural and synthesis modelling complexities. Physical modelling techniques have been quite successful at reproducing a large class of natural event types (rolling, scraping, dripping, breaking) combined with a variety of source types (strings, tubes, plates, bells) (Cook 2002, van den Doel 2001), but much work remains to capture the immense potential of the sonic world beyond speech and traditional instruments.

The art of creating synthesis models as parameterisations of classes of sounds is not only one of physical world imitation, but is also part of a broader musically creative process for which the composer needs better support than is currently available. An example problem at the heart of model building is that of creating a 'morph' from one sound to another (Wishart 1994). The work on this issue has tended to focus on various ways of interpolating between spectral shapes (Slaney 1996). A model-based approach would shift the focus to first creating a parametric space in which the sounds could both exist, the 'spectral space' being only one of the unlimited number of possibilities. After choosing the representation space, the many ways of traversing the space between the sounds can be addressed. By viewing the process of creating models as the musical activity of creating relationships between sounds and sound-producing objects, we see that the necessary tools for building them go beyond those for creating models as descriptions of a physical sounding object or process. The modelling process itself needs to be understood and supported with tools in much the same way it has been in the field of graphics, to make it accessible not just to engineers, but to artisans.

5. CONCLUSIONS

After Cage, 'there is no dividing line between musical sound and sound because all sound can be music' (Kahn 1990). However, admissibility is only the first of three phases necessary for the normalisation of sound in music. The 'problematic' of sound signification which remained following the radical admission of all sound was exacerbated, if not actually caused by the lack of technological means for any but the crudest level of control over sound generation available to composers of the twentieth century.

The exclusionary social and economic environment of early film and radio production, as well as entrenched musical training and practice, conspired to keep even existing technologies separated from musical practice during the early part of last century (Chavez 1937, Kahn 1999). However, when the technologies for recording and sound synthesis did make their way into the hands of artists and, with the advent of computers, made all sound theoretically possible, the free music called for by the early visionaries still did not make it into mainstream culture.

The problem remains a lack of technology for accessing any and all sound as freely and generically as a painter accesses form and colour. The modelling approach to sound and instrument design is beginning to enable access to the richness of the sonic world, and to the simplicity and subtlety of control necessary for instruments to be accessible and enjoyable for any musically inclined person, but the technique for creating and controlling sounds still significantly lags musical vision now as it has since Varèse pointed it out in 1917. The need for collaboration between engineers, scientists and musicians remains vital.

Technology is no panacea for the difficult questions that composers have raised in music over the past century, and in itself, cannot be the answer to a musical question. However, when we view some of the key historical developments of the twentieth century as solutions for exploring the entirety of the sonic domain in the context of a technological gap that composers themselves lamented, it clarifies the character of those historical developments. It also provides a sense of where music might go as the technological obstacles to our understanding and mastery of the sonic domain are overcome. Until that happens, it is still too early to write off the possibility that free music will one day move into the musical mainstream.

Almost all of the composers and authors of the manifestos cited above have expressed their sense of standing on the threshold of a new era. At the beginning of the last century, Busoni (1906) said, 'Music, compared with [the other arts], is a child that has learned to walk, but must still be led. . . . It is all unconscious as yet of what garb is becoming, of its own advantages, its unawakened capacities'. It is indicative of the magnitude of the shift in musical sensibility inherent in the discipline of sound and the vastness of the musical territory yet to be explored, that Wishart (1996) can say almost a century later: 'The era of a new and more universal sonic art is only just beginning'.

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