Composing with Time-Shifted Environmental Sound

Barry Truax

ABSTRACT

The author describes the compositional process involved in using sampled environmental sounds as the sole source material for his works *Pacific* (1990) and *Dominion* (1991). All sounds are heard at their original pitch but are processed using a time-stretching technique implemented in his software for real-time granular synthesis. In terms of timbral composition, the technique increases the perceived volume or magnitude of the sound. Such magnification allows the inner 'voices' of such sounds to be explored and their imagery and symbolism to be brought into the compositional process.

The ear needs a glass to magnify sound in time, which is to say slow-motion sound. . . . In drawing out the detail, in separating the sounds, in creating a sort of closeup of the sound, slow-motion can allow all beings, all objects to speak.

—Jean Epstein

Timbral Design Using Environmental Sound

The compositional concern for timbre and its design is central to contemporary composition. Timbre evades description in conventional musical notation, hence its exploration suggests a different musical domain from the rationalized two-dimensional field of pitch-time music. Timbrally based composition is less abstract than pitch-time music and more situated within the world of lived experience. J. Shepherd remarks that "as the essence of individual sonic events, timbre speaks to the nexus of experience that ultimately constitutes us all as individuals. The texture, the grain, the tactile quality of sound brings the world into us and reminds us of the social relatedness of humanity" [1]. In other words, an emphasis on timbre involves the listener in the real world of gender, environment and cultural symbols. Environmental sound used as compositional material has a particularly rich set of such references embedded within it [2].

Digitally sampled environmental sounds are the sole source material for my recent works *Pacific* (1990) [3] and *Dominion* (1991). For *Pacific* I used one sequence of sounds for each of four movements. The materials are recordings I made of Canadian West Coast environmental sounds, namely ocean waves on the west coast of Vancouver Island, boat horns in Vancouver harbor on New Year's Eve, Vancouver harbor ambience with seagulls, and the Dragon Dance celebrating the Chinese New Year in Vancouver's Chinatown. In *Dominion,* the materials are recordings of Canadian 'soundmarks' (e.g. bells, whistles, foghorns, cannons, etc.) recorded by the World Soundscape Project [4] during a cross-country tour. These materials are presented in an east-to-west direction suggesting a journey from 'sea to sea', divided into four sections, each depicting a region of the country. Each section includes a unique soundmark that signals high noon (the noonday gun in St. John's, Newfoundland; the Westminster chime and hour bell from the Peace Tower in Ottawa; a noon siren from a small town in Alberta; and the O Canada horn sounded daily at noon in Vancouver).

All sounds are heard at their original pitch in the final work but are processed using my time-stretching technique, implemented in the software for real-time granular synthesis that I developed [5,6]. Briefly, the technique works by controlling the rate at which new samples enter the signal processor's memory from which the grains are taken. The lack of any pitch change stems from the fact that the samples in each grain appear in exactly the same sequence as in the original sample; however, successive or overlapping grains may be repetitions of the same material, hence the time extension. In these works, sound densities ranging up to 2,000 events/sec per stereo pair of channels were recorded on 8-track tape and mixed down in the Sonic Research Studio at Simon Fraser University, Burnaby, British Columbia, Canada.

In terms of timbral composition [7], the technique increases the *perceived volume* or *magnitude* of the sound without necessarily altering its pitch or loudness [8]. First, there is the increase of spectral richness by the superposition of 12 versions (or 'voices') of the source per stereo pair of tracks. Such overlays intensify bands of spectral energy, whether those of resonances or noise elements. Second, the simultaneous voices are normally not phase coherent with respect to each other because of the randomness of synchronization created by the variable duration of the grains and the delays between them. This temporal independence of voices (in the range of phasing and reverberation effects, viz. less than 50 millisec [ms]) also results in an apparent increase in the volume of the composite sound. Finally, the time-stretching technique adds a third dimension to the perceived magnitude: spectra that are normally brief instants in time can now occupy virtually any time span. The result is that even noise-like spectra (such as water or percussion sounds) have their momentary resonances prolonged and magnified and thus are perceived as having larger-than-life vocal characteristics.

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My discovery of magnified 'inner voices' in environmental sounds suggested a compositional strategy in which these voices could be revealed as elements in a life cycle of death and rebirth through sounds common to the Pacific Rim. In the case of *Dominion,* the stretching revealed the inner harmonics within familiar sound signals such as bells, whistles and horns. My intent was to use the suspension of these sounds to give listeners the space in which to explore their own inner associations with this aspect of the Canadian cultural heritage. The inner and outer landscapes are thus merged at the symbolic temporal marker of noon or the New Year.

The time-stretching, however, also posed the compositional problem of how to structure the time flow of each movement. The stretched material, though timbrally rich and evocative, is generated at the expense of its temporal complexity—attack transients and amplitude variations are largely smoothed out into a steady-state continuum. Though mesmerizing, these sounds can cause aural fatigue if experienced for long periods. An equally serious problem is that, because most environmental sounds are broad-band, multiple tracks of this material are difficult to mix without extensive masking and loss of clarity. The wide range of frequencies contained in such sounds allows them to cover up or mask any other sounds of lesser magnitude in the same frequency range. The major compositional tasks in dealing with stretched sounds are to create both a temporal structure and a spectral balance.

Image and Metaphor in Environmental Timbral Design

Pacific

The technique of granular time-stretching that I have described provides a unique way to experience the inner structure of timbre, hence to reveal its deeper imagery. For instance, each movement of *Pacific* is based on the imagery inherent in the environmental sound used as its material. Moreover, in the composition of each movement, a metaphor is established that connects the sound to a deeper cultural symbolism.

In the first movement, *Ocean,* the literal title refers to the source material, which is a recording of powerful ocean waves on a coarse sandy beach. The movement's global structure is determined by a simple trajectory that begins with the waves at normal speed, gradually stretches them in time to reveal their inner voices and, at the end, rather abruptly returns the listener to the original version of the waves. To make the voices more apparent in the middle section, the high frequencies are filtered out and the frequencies associated with vocal resonances are emphasized through equalization. This process gives the added impression of a gradual submersion beneath the waves as their inner timbre is revealed, followed by a rapid surfacing at the end. The process of submersion is accompanied by the loss of the rhythmic pattern of the waves, which further heightens the illusion of entering a normally hidden realm. In the program notes, the voices are referred to as those of the 'unborn'.

The imagery and symbolism is traditional—water, life, and consciousness. Mythology throughout the world refers to the ocean as the mother of all life and the locus of the collective unconscious. We begin life as an emergence from amniotic fluid and later experiences of oneness of the self with the universe are often described as 'oceanic'. The listener to this movement is encouraged by its symbolism to identify the aural image of submersion beneath the waves as a descent into the unconscious, the repository of all symbolism, the aural manifestation of which is the blur of imaginary singing voices that emerge from the granular transformation of the waves. These voices are indistinct yet, strangely, human enough to evoke whatever images the listener chooses—hence the movement depends on the listener's participation for its completion.

The listener, however, may not be aware that other subtle 'illusions' are being played out in the movement. The first illusion is that there are voices in the sound of the ocean, and the second is that the rhythm of the waves is related to human breath. Again, the symbolism is traditional and ancient, but its implementation here is facilitated by the granular approach. The duration of grains used in granular synthesis is 10–50 ms or less, but there is nothing to prevent the composer from using longer durations that can be identified as macro-level events. In this case, the rhythm of the waves heard at the start is not their own but rather a superimposed 'long grain' pattern with an average duration of 3.4 sec. The illusion is created that these grains are the envelopes of waves breaking; however, as the movement unfolds, these durations are progressively shortened. The process continues even while these tracks drop out of the mix during the submersion sequence, but they appear later as short, energetic breaths of increasing speed and vigor that seem to trigger the final surfacing. The fact that the content of the short grains is from the original waves gives it the noise-like character of breath. Hence the movement can be understood as a process of giving birth, of air replacing water. Such a separation is not without trauma, hence the unsatisfying sense of abrupt cadence. Also, in the background the careful listener may detect a raven at the beginning and end. In aboriginal West Coast imagery, Raven is simultaneously a creator and trickster.

The second movement has a metaphoric title, *Fog,* and attempts to recreate an environmental experience often found on the Canadian West Coast, a blanket of fog in a harbor surrounded by mountains. However, it does so by using sonic material unrelated to fog, namely boat horns recorded on New Year's Eve. The sustained boat-horn sounds are stretched even further to create a texture of seemingly timeless proportions. The movement starts with the assertive E-flat minor triad of the Canadian Pacific Railway (CPR) ferry horn, and after it dies away more distant horns are revealed. The reverberation of these horns in Vancouver harbor (the sound reflects across the water and bounces off the mountains) blended these sounds in the original recording into a smooth texture that is enhanced by the time extension. Some of the lower-pitched horns begin to resemble voices, while the higher-pitched sounds come from the actual voices of young people who were welcoming the New Year. Time extended, these voices transform into long musical notes, and throughout the movement there is an amorous interplay between all of these tones. Hence in the program notes, the inner voices are referred to as those of lovers.

Unlike the other movements, *Fog* uses 12 component tracks, which, after the initial ferry-horn fanfare, are designed to blend seamlessly, like the visual effect of fog in an environment. However, even within this 11-min suspension of breath, some underlying temporal structure seemed to be needed, apart from the natural progression and eventual cessation of the horns in the original recording. This structure is subtly present in two forms.

The first is a series of percussive gestures, modelled after the boat horns themselves but which in fact consist of 'frozen' moments of their timbres. This technique is achieved in the so-called 'continuous' model of granulation, in which the material is re-synthesized at the original speed, but the signal processor's memory may be frozen at any moment by the composer and its contents used to supply a series of grains. Further, the composer may specify a rate of decay to this material and the amount of feedback (if any) of this material into the next 'frozen' moment. In the course of the movement, these percussive elements appear in the first half and recede in the second.

The other spatial/temporal element in this movement is a quadraphonic panning of four channels of the source material in the clockwise direction simultaneously with quadraphonic panning of another four channels counterclockwise. Of course, this is heard only in the four-channel version of the piece, though an analogous panning is attempted in the stereo mix. Because the rate of rotation is relatively slow, it is not expected that the listener will be very aware of it. However, there is a constant interplay between gradual metamorphosis and the seeming stasis of the movement; the environment seems stable, yet it is always changing. The image of dislocation created by being shrouded in fog becomes a metaphor for the merging of selves experiencing love.

In the third movement, *Harbor,* we return to a literal title and the sound of water. However, here the water is the seemingly domesticated wavelets that lap invitingly on the shore in a protected environment. These sounds are background to the raucous cries of seagulls as they fight for food, contrasting with the solitary raven heard in the background of the stronger waves of *Ocean.* As the movement progresses, so does the amount of time extension given these cries until they become long lyrical songs of striking complexity—a metaphor for the inner wisdom of age that often lies behind a weathered exterior. In this case, the idea of inner voice is a different kind of transformation—the actual voice of the bird, which most listeners find irritating, becomes musical through the use of time extension, which allows this sound to be heard up to 75 times more slowly than normal.

The structure of the movement loosely follows that of *Ocean,* with which it shares other similarities, namely that it begins with apparent naturalism and progressively introduces increasing levels of transformation, aided by equalization to emphasize certain resonant frequencies. The full range of transformations possible with both 'continuous' and 'variable-rate' modes of granulation [9] are used to impose phase modulation, gating, feedback, and stretching of the material. The use of envelopes of 'frozen' moments of the material becomes increasingly insistent in the second half of this movement, ending with events with long attacks, reminiscent of the breath motif of the first movement. These sounds reinforce the increasingly prominent stretched sounds of the bird cries, and the movement ends with an upward octave leap found in one of them. In terms of the related imagery, the movement takes the sounds of nature, now domesticated and familiar within the protective environment of the city harbor, and delves into them with obviously imposed compositional techniques. In the result, I hope that the listener discovers a hidden beauty that is metaphorical to the wisdom of age, which discovers essential truths in life experiences.

The final movement, with its metaphorical title *Dragon,* is the culmination of the work, but it was also the starting point for the composition. Its materials were developed first, and the other movements were composed in reverse order to arrive at it. The source material is comprised of the spectacular percussion sounds of the Dragon Dance celebration of the Chinese New Year, including drums, cymbals and strings of small firecrackers that are set off when the Dragon, seeking to be appeased, approaches one of the storefronts. These sounds are time-extended to the point where they suggest the fury of the mythical Dragon. In contrast to the sounds of the Canadian New Year in *Fog,* which I compared with the voices of lovers, the inner voices, revealed when I stretched the sounds from the Chinese New Year, suggested those of the dead. However, as in many celebrations of cyclical phenomena and in the image of the Dragon devouring its own tail, this ritual reminds us that we must confront death in order to welcome the promise of new life symbolized by the New Year.

The structure of this 14-min movement is a microcosm of the work as a whole: four sections alternating energetic and sustained moods. The sustained sections use the same quadraphonic rotation system as the *Fog* movement, and particularly towards the end of the piece, the image of inner voices is similar to those heard in *Ocean*—hence the sense of life cycle. The rhythms found in the two energetic sections are modelled after the two principal component sounds of the original recording, the drums and firecrackers, respectively. In the first section, the repeated rhythmic pattern of the drums was imitated and accompanied by a short loop of the firecrackers that advanced approximately 0.2 sec with each repetition to produce complex syncopated rhythms. This material was processed with a digital comb filter to add a rising and falling sense of pitch. In the second energetic section, the sound of the firecrackers is processed in a variety of ways to suggest the buildup of tension and excitement to a climax marked by the recording of the string of explosions (the only untransformed sound in the entire work). In the sustained sections, the stretched sounds of the drum resonances provide a deep bass presence, the cymbals a sizzling, broad-band fiery sound, and the cries of the dancers some kind of netherworldly voices (those in Purgatory?). Together, these sounds create an image of the Dragon or Phoenix and suggest the metaphor of death and renewal. The solo version of this movement, *Pacific Dragon,* includes computer-graphic images by Theo Goldberg that use traditional Chinese-dragon motifs as their source.

Dominion

A similar play on the inner imagery of environmental sounds is explored in *Dominion,* however the references are to the history of a country (Canada), not of an individual. The structural cycle of the piece is formed by a voyage across the country by train, the construction of this transcontinental link being fundamental to the political union and the psychological myth that created the country. The title of the work refers to Canada's official status as a nation, a designation suggested by Sir Leonard Tilley, one of the Fathers of Confederation, based on Psalm 72: "He shall have dominion also from sea to sea, and from the river unto the ends of the earth." It is not coincidental that the piece was composed at a time when this confederation was in serious jeopardy.

The work starts with the noon gun in St. John's harbor, Newfoundland, and is followed by various foghorns and other whistles from the East Coast. In the middle section, the noon chimes and hour bell of the Peace Tower in

Ottawa are played out in counterpoint against the bells of the Basilica in Quebec City (a dialogue whose political equivalent is frequently acrimonious). The ubiquitous E-flat minor triad of the CPR train horn connects the various sections. In the Prairies we hear the noon siren from a small town in Alberta, along with various typical ambient sounds such as wind in a wheat field and a humming power line, both evocative of the largely flat landscape. Another set of horns and whistles announces the arrival in British Columbia at the Rocky Mountains, and the piece ends at noon in Vancouver with the daily sounding of the O Canada horn, so named because it reproduces the first four notes of the national anthem.

The attack portion of each sound is kept largely intact, in order for it to be easily recognized, while the main body of the sound is prolonged, often 50 times or more. The harmonics inside these dramatic and unique sound signals on tape are matched by pitches produced by a group of 12 performers (string and woodwind quintets, plus trumpet and percussion—all amplified) spread out on stage in a configuration similar to the geographic arrangement of Canada's 10 provinces and two territories. Ideally in a performance, a centrally placed mixer operator distributes these sounds (both those that are live and those on tape) to eight or more speakers placed around the audience. The conductor, who functions as a timekeeper, indicates the beginning of each section by bringing his/her arms together like the hands of a clock approaching 12 noon. The score allows the performers certain freedoms within each 6-sec time span, with cues provided by the conductor to coordinate with the tape.

All of this symbolism is designed to involve the listener, particularly a Canadian one, strongly in the musical process, by presenting a larger-than-life image of sounds that are strangely familiar. Whereas a simple collage of the material would provoke recognition of it only as sound effects, the time-stretching allows the listener to be drawn into the sound and evokes its imagery and associations. The process results in what I have described as a music of complexity [10], a music that is strongly contextualized, in contrast to music composed within the dominant paradigm, in which sounds are related only to each other, creating completely abstract works of art.

CONCLUSION

A music of complexity finds its basis in the unique contexts of the real world. These include its physical attributes (space and time, acoustics and environmental character), its social situations (specific individuals, groups, 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 works in the Western classical tradition are usually analyzed, but from its external relations as well. This simultaneous motion inward and outward provides a way of integrating sound and structure, the separation of which has been a hallmark of the instrumental music tradition [11]. The abstract work of art grows out of a similar division between art and context. In short, a music of complexity allows not only the rift between sound and structure to be healed, where the two are inextricable, but also the division between music and context to be healed. Both art and environment have deteriorated with their separation, and a reunion cannot come too soon.

The dominant electroacoustic-music techniques today that deal with prerecorded sound material, in both commercial and art music, involve digital signal processing as 'postproduction enhancement' and digital samplers whose musical usage may be termed 'composing with sound'. The compositional thinking found in *Pacific* and *Dominion* proposes a different approach that may be termed 'composing through sound'. In this approach, processing techniques are used to reveal the inner levels of meaning and symbolism contained within the timbres of familiar sounds. Instead of 'using' the sound, one is 'used' by them, in the sense that their inner character informs the resulting music. By reversing the imperative of the domination of nature, which leads only to its destruction, we may be able to (re)create models of a more balanced relationship between ourselves and the environment.

References and Notes

1. J. Shepherd, "Music and Male Hegemony", in R. Leppert and S. McClary, eds., *Music and Society* (Cambridge: Cambridge University Press, 1987) pp. 163–170.

2. T. Wishart, "Sound Symbols and Landscapes" in S. Emmerson, ed., *The Language of Electroacoustic Music* (London: Macmillan, 1986).

3. B. Truax, *Pacific Rim*. Vancouver, British Columbia: Cambridge Street Records, 1991. Compact disc CSR-CD 9101. Cambridge Street Records, 4346 Cambridge St., Burnaby, British Columbia, V5C 1H4, Canada.

4. B. Truax, *Acoustic Communication* (Norwood, NJ: Ablex Publishing, 1984) pp. 75–79.

5. B. Truax, "Real-Time Granular Synthesis with a Digital Signal Processor", *Computer Music Journal* **12**, No. 2, 14–26 (1988).

6. B. Truax, "Time Shifting of Sampled Sound with a Real-Time Granulation Technique", *Proceedings of the ICMC* (San Francisco: International Computer Music Association, 1990).

7. For more detail on the 'sound/structure' and timbre theme as developed here, as well as a summary of the author's previous experience with granular synthesis, see B. Truax, "Composing with Real-Time Granular Sound", *Perspectives of New Music* **28**, No. 2, 120–134 (1990).

8. B. Truax, "Musical Creativity and Complexity at the Threshold of the Twenty-first Century", *Interface* **21** (1992) pp. 29–42.

9. Truax [6].

10. Truax [7].

11. Truax [7] pp. 120–121.