Frontispiece. Thanos Chrysakis, a view of the *Encounters* sound installation, 2005. (© Thanos Chrysakis)
Spatio-Aural Terrains
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Received 23 December 2005.

Auditory Spaces
Composers have always created auditory spaces of different dimensions—that is, different kinds of musical spaces, from two-dimensional space (a simple melody) to more elaborate auditory dimensions (the dimension of depth through the permeability of the sounds, the dimension of directionality through their various speeds and movements and so on). Multidimensional composed auditory spaces can be found in—amongst other places—fugues, sonatas and contemporary music that uses net-like structures, soundmasses, polyphonic multi-layering, etc. On the other hand the question of sound and physical space is addressed in a long tradition from, to name but a few, Andrea Gabrielli and Giovanni Gabrielli to Thomas Tallis up to György Kurtág and Luigi Nono.

In my compositions my urge to deal with various dimensions plays a prominent role, but my equal interest in the notion of physical space has found a liberating fulfillment within the artistic practice of sound installations dealing with auditory spaces and physical spaces at the same time.

Auditory Spaces in Places
In an interview [1] about The Elephant Man, director David Lynch described the way he was inspired about the particular feeling that London might have had at the time of the “elephant man.” While in London for the shooting, he found inspiration and ideas from books about London more than from London itself, because not every place that he went to was Elephant Man territory; nonetheless, one day he found himself walking around a derelict hospital and at a particular moment he knew what it used to be, living back then, in this city. “The Dasein is in the Atmosphere,” as Michel Serres says [2].

I mention this anecdote to show how I am interested in places. There are different ways of approaching sound installations, and my practice is to construct computer algorithms or multichannel soundscapes that are played through different kinds of speakers in particular buildings or rooms.

Working within this framework demands that I accumulate details from the specificity of the place—in other words, create a fruitful dialogue with it: learning about its history, trying to perceive its own singularities, taking into consideration its shape and using found material within it.

The sound has to come as a catalyst to the space, contributing to the spatial presence of it, to make it more present to the visitors. There is no decoration, “beautification” or functionality of the type of music for airports, malls and restaurants; the space is conceived as the performer of the work, in the sense that without it, the work is not realized. My motivation within the practice of sound installations lies in the idea of creating an intervention of sensibilities crossing personal and public boundaries/spaces.

Spatio-Aural Borders/Spaces of Co-Existence
Resonator is a sound installation conceived for the Château de Linardié, in a small village south of France.

An old barrel at the basement was used as a resonating chamber for my generative electronic soundscape (Fig. 1). A laptop and two small speakers were placed inside the barrel. This object functioned as a resonator and amplified the microsonorities in such a way that the sounds of the environment could still be heard and fused with those of my generative audio system. The room had a dim light, so if someone were to be drawn close to it then she or he would see from some holes on the barrel a monitor showing the spectra of the sounds in motion.

In February 2005 my generative micro-textural audio system Encounters, which uses stochastic processes and permutations, was presented at Goldsmiths. It was placed in a room with very big windows, so changes of the natural light could be perceived by those who visited the place twice.
I created two squares in the middle of the room. The outer square consisted of four loudspeakers while the five chairs in each side represent the inner square (Frontispiece).

The listeners, according to where they chose to sit, had a different acoustic perception of the spatiality of the sounds. The volume of the sounds was such that at times it would dominate the space and at other times would integrate with the sounds of the environment.

Because the natural light changed throughout the day there was an interesting integration not only with the sounds of the environment but also with the slight micromovements of the natural light. In the evening there was an interesting contrast as one listened in the dark. Sounds of the environment being masked during the day started to unfold as the environment became quieter during the evening.

References and Notes

Thanos Chrysakis is a composer/installation artist currently undertaking Ph.D. research at the Electronic Music Studios, Goldsmiths College, University of London.

TOWARD A POST-PHENOMENOLOGY OF EXTRA-MUSICAL SOUND AS COMPOSITIONAL DETERMINANT
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Received 22 May 2006.

For a number of years, I have been developing a musical language from extra-musical study of auditory perception, recorded sound and architectural acoustics. My practice has its roots in the experience of sound in space as an explicit concern. In a given piece the listener’s phenomenological experience of the acoustic potential of both the room and the instrumental or electronic forces employed help inform my decisions regarding content, discrete and semantic pitch choices, rhythm, tempo and form.

It can be argued that the experience of music is an inherently phenomenological enterprise. In the late Renaissance antiphonal choral works of Palestrina, the offstage trumpets of Verdi’s Requiem, Bruckner’s attention to the acoustics of his basilica, Wagner’s orchestra under the stage, and in countless other examples, composers have made anecdotal and implicit use of space in the performance of and compositional process in their works. In the 20th century, work by Brant, Cage, Lucier, Oliveros, Radigue, Sclci, Vanèse, Xenakis, Young, the spectral school and others has brought the experience of acoustics to bear as a much more explicit component of their methodology. Most recently, in the sound artworks of Cardiff, Kuhn, Kübisch, Leitner and Minard, these concerns have been liberated from proscenium presentation and brought out into greater architectural space.

It is in the spirit of these explorations of space through sound that I began my inquiry.

I invoke the term post-phenomenology in my work to show that phenomenology is taken into consideration, acknowledged as important and then moved beyond. I am interested in the potential of systems embedded in the stuff of acoustics and perceptual science that may be capable of generating new materials for expression. My hope is that these materials are robustly connected to some of the many ways in which people hear the world. I am not interested in the exploitation of acoustic or perceptual effects as such, but rather in extending the traditional musical language systems of orchestration, counterpoint, harmony and form by exploring the way in which sound moves through space and the manner in which people perceive sound in a media-saturated and pervasively technologized world.

Pitch and orchestration have often been treated as separate categories in compositional practice. However, when considering a sentient, perceivable connection between the sound of the ensemble and the space in which the ensemble is performing, the two are inseparable for me. Composers often abstract pitch to the level of semantic signifiers and develop its semiotic content separate from its spectral content. Orchestration is often seen as an additional step in which tone color is applied to the pitches at hand. This is often true even in instances in which the orchestral idea comes first. Consequently, the two systems are traditionally treated as discrete elements; although they often work together, they are rarely fused. For me, both pitch and orchestration comprise the complete frequency component of the auditory scene as such, serving as active agents in the process of producing a space in which listeners feel connected to the work.

Much of my practice has consisted of concert pieces and installations making use of sine tones, acoustic instruments and amplified objects, and field recordings that are tuned to the spaces in which they are performed. In these pieces I have been developing the relationship between sine tone pitches and a given room’s acoustic signature. Over time, the contrapuntal relationships between the pitches themselves become intricately connected to the acoustics of the space, the instruments or field recordings employed, and the experience of the listener. In addition to these contrapuntal complexes, I have found that using sine tones in conjunction with the acoustics of a room affords access to psycho-acoustic phenomena such as masking, precedence effect, just-intoned harmonic relationships, additive tones and more.

Through an extension of pitch, counterpoint and orchestration, form can be explored in not only linear but also spatial terms. A composition thus emerges as a space more akin to the multidimensional space of everyday listening habits with their myriad possible interpretations and affordances. The ears that one uses outside of musical experience can feel connected to the musical event in an inclusive synergy. It is in this way that I see the exploration of the musical composition as a trace of the manner in which one hears the world.

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SLOWLIFE: SONIFICATION OF PLANT STUDY DATA
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Received 24 October 2005.

SLOWLIFE is an exhibit about plant biology at the United States Botanic Gar-
den [1]. I provided the sound. The premise of the exhibit is that changes in the lives of plants happen too slowly for us to notice. The exhibit features time-lapse videos of plant growth, some at the microscopic level. By speeding up the depiction of plant growth processes, we humans—distracted as we are by our fast-moving, multitasking world—can develop an appreciation for them.

I sought to provide a sonic environment that helps visitors ease into a contemplative frame of mind. The sound is soft and slow moving, coming across as an auditory analog of the slow changes in the lives of plants. Three stereo streams are deployed in the exhibit space in such a way that a visitor moving from one part of the exhibit to another experiences a variable mix between the streams. I designed the sound so that each stream loops over a different time span, and the initial combination never repeats.

There is a further dimension to the sound: All the textures are constructed, to varying degrees, using data from the experiments on which the exhibit is based. I wrote programs to extract data sets and map them to appropriate musical dimensions for realization within RTcmix, a sound synthesis and processing package that I develop with colleagues [2].

As I worked on the sound, I wrestled with the issue of the audibility of sonified data. This is not a new idea: think of Dufay’s 15th-century motet “Nuper rosarum flores,” which is based on the dimensions of Brunelleschi’s dome [3]. It was probably enough for Dufay to know that his piece shared architectural details with the dome—confirming a Platonic ideal of harmony—without expecting anyone to hear this structure. Contrast Dufay with Steve Reich, who insists on audible process rather than conceptual justification [4]. To hear his Piano Phase well is to follow the phase-shifting process and to realize the importance of the moments when parts realign. Where does that leave sonification of plant study data? Must the data have an audible result?

I try several approaches. For one texture, I take the changing measurements of seedling curvature in response to light and map these to the rhythm of synthetic bell notes. This sound accompanies a montage of many time-lapse videos of seedlings bending toward light (Fig. 2). The individual videos have an unsteady appearance and they loop over varying time spans. The total image is a delightful interaction of many similar seedling “dances.” Because the mapping of curvature data to rhythm is so straightforward, and because the sound itself is simple—only four pitches repeating throughout—it is easy to perceive a general correspondence between visual images and sound.

For another texture, I let the experiment data remain subordinate to my musical intuition, with the result that the effect of the data on the sound is not readily identifiable. The experiment treats plants with varying strengths of blue light and records the fluctuating amount of light transmitted through leaves. Each sustained note in this texture comprises multiple oscillators with variable tuning. As a leaf lets more light through, the oscillators diverge from matching each other in pitch and so sound more “out of tune.” However, I control the depth of these tuning changes intuitively, by reacting to the sound while turning a knob. Moreover, I rely on my sense of harmonic quality and motion when selecting pitches. It turns out that the aspects of the sound under my intuitive control are far more noticeable than the ones under the influence of the experiment data. In this case, then, the link between the data and the sound is more conceptual than audible.

The text accompanying the exhibit informs the visitor that the sound has some basis in the experiment data. Can visitors hear this connection? Does simply knowing about the connection affect the way visitors perceive the sound—perhaps by assuring them that the sound moves beyond mere mood enhancement—even if they cannot hear the effects of the data directly? Questions like these are important for anyone considering sonification in an artistic context.

References and Notes
1. S.Laudisi was designed by Roger Hangarter and Dennis DeHart. See <slowlife-exhibit.org>.
2. For more information about RTcmix, see <rtcmix.org>.

Fig. 2. Roger Hangarter and Dennis DeHart, 101 Tropisms (excerpt), video montage with sound by John Gibson, 2004. (© Roger Hangarter and Dennis DeHart)

John Gibson’s acoustic and electroacoustic music has been presented in the U.S.A., Canada, Europe, South America and Asia, including at the Seoul International Computer Music Festival, the Bourges Synthèse Festival, the Brazilian Symposium on Computer Music, the International Biennial for Electroacoustic Music of São Paulo and Keio University in Japan. Gibson holds a doctorate in music from Princeton University. He writes sound processing and synthesis software, and has taught composition and computer music at the University of Virginia, Duke University and Indiana University. He is now assistant professor of composition at the University of Louisville.

**HEAT AND THE HEARTBEAT OF THE CITY: SONIFYING DATA DESCRIBING CLIMATE CHANGE**

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According to a 1999 report of the Environmental Defense Fund, New York City will be dramatically impacted by global warming in the near future. Average temperatures in New York could increase by 1–4° Fahrenheit by 2030 and up to 10° by 2100. According to the Metropolitan East Coast Assessment, the impacts of these changes will be great [1].

**Heat and the Heartbeat of the City** (launched 1 December 2004: <www.turbulence.org/works/heat>) is a website that presents a series of sonifications illustrating projected climate changes focusing on the heart of New York City and one of the city’s first locations for climate monitoring, Central Park (Fig. 3). Listeners travel forward in time at an accelerated pace and experience an intensification of heat in sound. In addition to the web site, the project has been presented as a multichannel stereo headphone and speaker installation.

To produce *Heat and the Heartbeat of the City*, I worked in collaboration with Cynthia Rosenzweig, David Rind and Richard Goldberg at the NASA Goddard Institute for Space Studies and Columbia University. Rosenzweig is a senior research scientist and the leader of the Climate Impacts Group. She focuses her research on the impacts of climate variability and change on systems and sectors at regional, national and global scales. The Climate Impacts Group had created one of the most detailed climate models of an urban area. They provided me with actual data from summers in the 1990s and projected data for summers in the 2020s, 2050s and 2080s formatted especially for the creation of sonifications.

As part of the development of the sonifications, a series of videotaped discussions with Rosenzweig were held and placed on the site. Through the discussions, I took note of indicators in the data connected with effects on the population. One clear indicator was that the effects are amplified when there is a buildup of hot days. For example, each consecutive hot day sees an increase in energy load and emergency room visits. In order to express these negative effects, I not only mapped the sounds to the temperature values directly, but increased the intensity of the sound when groups of consecutive hot days were found.

The sonifications focused on expressing the effects of days over 90° Fahrenheit, an uncomfortable temperature. If the number of consecutive days over 90° increased, I would attempt to create an “uncomfortable” change in the sound.

I increased the intensity of the sound by increasing the pitch and loudness. In previous work with storm data, I used the data to control the filtering of source sounds with a wide frequency spectrum [2]. For this project, I filtered similar source material using temperature data. On comfortable days, filtering was increased to create cleaner sounds. As heat increased, filtering was reduced, creating more noise.

The speed at which the data was translated into sound played a significant role. The Climate Impacts Group provided one value—average daily temperature—for each day during the summers (approximately 90 days) of each of the 10-year periods. That translated into approximately 900 values for each decade. I wanted to give listeners a detailed sense of the climate...
of each decade while still creating a listenable composition, so each of the final compositions were approximately 7 minutes long, reading and translating approximately 2 temperature values per second. A smooth transition between each value was made using digital signal processing in Max/MSP. Although the sonifications focused on temperature, the sonification of an additional variable, precipitation, was added to provide more variety to the compositions.

The sonifications were created in Max/MSP using the custom object Datareader. I developed Datareader with the help of programmer and video artist Kurt Ralske (<www.miau-iau.com>). The Datareader software and its source code are available at <www.andreapolli.com/datareader>.

The final sonifications were placed in an on-line interface (Fig. 3) combined with an image that changed color from green to brown to red as the projected warming increased.

In this project, time and space are compressed in an attempt to allow listeners to hear the patterns of natural systems, perhaps comparing these sounds to the sounds of the natural world. The work uses sonification as a way to construct a kind of narrative, emphasizing a climate phenomenon that affects human life negatively and compressing a 90-year time scale involving millions of people into an individual experience of minutes.

References and Notes

1. The Metropolitan East Coast Assessment is accessible at: <metroeast_climate.ciesin.columbia.edu>.


Andrea Polli is the director of the MEA Program in Integrated Media Art at Hunter College in New York City. Her art and science projects are hybrids that feed into multiple areas of research and offer new “readings” of natural systems.
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