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# Symbiotic Milieu: Gardens in Movement, and Gardeners in Music

Whitehead Lecture in Cognition, Computation and Culture  
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Professor Tanaka,  
Distinguished colleagues,  
Ladies and Gentlemen,

I would like to begin by expressing my deep gratitude to Professor Atau Tanaka and the organizing committee of the Whitehead Lectures for inviting me to speak here today at Goldsmiths, University of London. It is a great honor to address you in an institution that has been pioneering in articulating the relationships between arts, cognitive sciences, and computational technologies. This lecture is part of ongoing research-creation work conducted at the Centre de Recherche Informatique et Création Musicale at Université Paris 8, and it mobilizes tools developed within the ANR BBDMI project led by a team which includes Professor Tanaka.

I am a composer, researcher, and landscape architect. This triple formation structures all of my scientific and artistic questioning. My research-creation projects explore a central hypothesis: that listening can become a means of attending to the living—that is, of becoming attentive to it and caring for it. This hypothesis has been tested in several compositional frameworks, two of which I will present today. These projects utilize tools from the ANR BBDMI project.

These projects are rooted in the observation and practice of a garden that served as a laboratory for my work: the garden of the Maison des Sciences de l'Homme Paris Nord, which I will describe shortly. This work engages with the broader conceptual framework of what I call "*faire-jardin*"—or "make-garden"—in music, an approach that extends beyond the aesthetic or functional act of gardening to encompass the processes of care, cohabitation, and interaction between human and non-human agents in a shared environment.

## I. A Garden in Movement at the Heart of a Post-Industrial City

Before diving into the projects themselves, I need to introduce you to this garden that became the site and subject of my research. The MSH Paris Nord garden was built on former industrial wastelands in Saint-Denis, a suburb north of Paris. The competition for the building was won by the architecture firm SEARCH (Caroline Barat & Thomas Dubuisson) in 2007, while the landscape design was entrusted to the Mutabilis agency (Juliette Bailly-Maitre & Ronan Gallais). The building and garden were completed in 2015 as part of a broader requalification of post-industrial land in Saint-Denis. In this plot of land, the soil remains heavily polluted with hydrocarbons and heavy metals, reflecting the site's industrial past.

The MSH landscape project engaged with a site that can be described as a "negative commons"—a polluted, abandoned industrial ruin that we seek to transform into a space for cohabitation. The

landscape design follows the principles of the "Garden in Motion," a method theorized by the landscape designer and gardener Gilles Clément. This approach to landscape design emphasizes observing plant self-organization before any intervention. At the MSH, the landscape designers were inspired by this gardening technique. Following an initial planting phase, the garden was then largely left to evolve on its own. From 2015 until my arrival in September 2021, it remained largely unmanaged, revealing new forms of ecological self-organization and resilience.

It is within this dynamic that I reflected on the notion of symbiosis through what I call, inspired by the thought of Dominique Guillo, an "adjustment of differences." In this way of gardening, the word "management" is not appropriate. Gilles Clément talks more about "*conduire le vivant*"—that is, "guiding the living," or "making-with" the living. This garden thus reflects the ways in which diverse agents—human, vegetal, and technological—co-create, in a way, a shared space through processes of adaptation rather than assimilation.

By observing this self-organizing garden, I began to see parallels with musical composition: How can we draw inspiration from these dynamics to structure musical material? How might this inform the design of sound installations? However, an important consideration emerged: without human intervention, the garden tended toward a state of closure, resembling an urban wasteland rather than a garden. I think this sheds light on the idea that collective ecological awareness is not only about preserving environments but also about actively engaging with them through acts of listening, attunements, and transformation.

## **II. LICHENS: Rebuilding Attachments**

This is where my dual experience in landscape and music became crucial. I sought ways to reconnect people to this garden by integrating it into my doctoral research. Indeed, before my arrival, the garden was an "unthought"—researchers did not even know they had a garden. The first project stemming from this research work is LICHENS (Liens, Instruments, Coopérations et Création, Handicaps, Écoute, Numérique et Symbioses), a collaborative initiative fostering symbiotic relations between different actors in the garden. It connected various gardening and musical projects within an ecosystemic framework.

I will focus particularly on the work we conducted with the ESAT Vivre Autrement. For those unfamiliar with French social structures, an ESAT is a medical and social establishment providing sheltered employment aimed at the social and professional reintegration of people with disabilities. The gardeners from this ESAT are responsible for maintaining the MSH garden. Through gardening workshops, sound walks, studio sessions, and concerts, LICHENS attempted to foster new forms of attentiveness to the living.

### **The Gardener's Ear: Developing a Methodology of Listening**

One central aspect of the LICHENS project was to develop a methodology of listening that resonated with both music and gardening. I conducted workshops combining gardening practices with listening exercises, including field recording. The gardeners explored different auditory perspectives, comparing direct listening with stereo and binaural microphone recordings.

The use of recording technology became a powerful pedagogical tool, helping participants articulate their sonic perceptions and fostering an evolving autonomy in describing the garden's soundscape. Some gardeners even chose to record the sounds of their own tools, such as the brush cutter. These exercises revealed an alternative dimension of the garden—one understood through plural and diversified auditory attention.

[At this point in the lecture, I would play an audio excerpt: the environment of the Garden of the MSH Paris Nord recorded on April 11, 2023, at 8:53 AM, with a Zoom H6, 48 kHz, 24 bits, no processing, approximately 1 minute 16 seconds.]

We can also listen to an audio recorded by the gardeners themselves, where they comment on what they hear, in French.

[Second audio excerpt: Recording of the gardeners' listening impressions, May 23, 2023, between 2 and 4 PM, with a Zoom H3-VR, 48 kHz, 24 bits, stereo rendering of a 4-channel ambisonic recording, approximately 3 minutes 35 seconds.]

### **Listening Again: Immersive Experience in the Studio**

In our final studio workshop, we listened to ambisonic recordings of the garden through a 16-loudspeaker dome. This immersive experience immersed the gardeners in another way of listening. We discussed what one perceives from a soundscape when other senses such as sight and smell are not engaged. The gardeners discussed how this way of listening highlights fine details and tends to emphasize the perception of low frequencies. Some gardeners compared this experience to cinema, while others noted the richness of the soundscape's textures.

### **Improvising and Listening to Each Other: Building an Instrument**

The second part of the studio session introduced the gardeners to real-time transformations of these recordings using BBDMI project tools—specifically, a system that translates body electricity into variables that can be mapped to musical parameters. To facilitate engagement for non-specialists, I designed an interactive sound-processing system controlled by three participants using electromyography (EMG) electrodes and a controller.

The first transformation applied was ring modulation, which created movement and circular sound trajectories. The second was decorrelation, which produced clouds of spatially distributed sound particles. The third was a complex frequency shifting, which altered the harmonic spectrum. Each gardener controlled one parameter, allowing for collaborative improvisation and reinforcing the idea of composition as a collective, emergent process.

In addition to auditory feedback, gardeners had access to the Max patch's presentation-mode interface: they could observe muscle activity curves, the display of the decorrelation coefficient (labeled "distribution" to illustrate the spatial distribution of sound particles), and the display of the modulation frequency for ring modulation (labeled "trajectory" to simplify a perceived effect).

With this instrument, transformations can be experimented: one after the other or combined to build complex syntheses of sound space. With each transformation controlled by a gardener, groups of three were able to experiment and improvise. They could play with a treatment that had become an instrument. They improvised, listening to the transformations and reacting to the transformations carried out by their improvisation partners. During the studio workshop, we made breaks for regular feedback on the gardeners' impressions.

### **Imaginary and Recomposed Listening**

In this way, using gestures to handle 3D sound processing enabled the gardeners to experiment with a different kind of listening: listening composed through musical gesture. The transformations effected on the sound space enabled them to apprehend other types of sound environments.

Although constructed from recordings made in the garden, the composed spaces became abstract, unrecognizable, and called up other imaginaries and representations. From this experience emerged a new diversity and kind of attention, as well as a new polyphonic milieu.

One gardener remarked: "I feel like I've traveled to a misunderstood universe, to another world. [...] I feel like I was on a plane and I landed."

In this experience, BBDMI tools facilitated the appropriation of a real-time musical practice by non-musicians. These interfaces facilitated what I call "gardening" in music—that is, composing a sound environment in which it is possible to explore diversified morphologies that are always in motion, to stimulate listening that is also always in motion.

I will now present a second project that reflects on the concept of symbiosis and explores ways to engage in co-creativity with non-humans.

### **III. Mycelia, Fungi, Signals, and Symbiotic Networks**

This second project explores underground networks. I am not the only researcher to say this, but the underground world is often overlooked, perceived as a mere surface rather than as a living ecosystem. Though in the underground, the mycelium—an underground vegetative organism—forms complex interspecies interaction networks and symbioses that are essential to life. What we see of it, season after season, are the mushrooms, which are the reproductive organs of the mycelium.

As a composer, I wondered: How can I reveal the living nature of mycelium and make it audible? What tools can I build to "listen" to this living organism? How can I compose with it, attempting to establish a relationship—if such a thing is even possible—with mycelium?

#### **A Brief Scientific Context**

Since 1873, it has been known that plant cells conduct electrical signals. Burdon-Sanderson, a British physiologist, was the first to identify action potentials in plants. More recently, other scientists have demonstrated the presence of action potentials in fungi—which, importantly, are not plants—and in mycelial networks.

For example, in 1995, Olsson and Hansson measured electrical signals in the mycelium of the fungus *Neurospora crassa*. More recently, Dehshibi and Adamatzky, through multichannel analysis, uncovered the complexity of signal transmission systems in the mycelial network of *Pleurotus ostreatus*.

#### **Searching For, Cloning, and Growing Mycelia**

For this project, I brought together a team with whom we worked to create a sound installation that attempts to reveal the vitality of a mycelial network by making its electrical expressions audible. The team included Anne Sèdes, Alain Bonardi, and David Fierro from CICM–MUSIDANSE at Paris 8; Guillaume Peureux and Julien Schuh from CSLF at Université Paris Nanterre; Charlotte Janis and Roberto Dell'Orco from SPORA; Stephen Whitmarsh from ICM; Hugo Scurto, a postdoctoral researcher with ArTec; Salim Mohamed Aissi from LIP6; and technical support from Adrien Zanni and Paul Goutmann for the ambisonic and WFS setups. We used BBDMI tools and libraries throughout.

We began by observing the mushrooms present in the garden of our laboratory. We found an *Agaricus* that seemed to be a good candidate for cloning. Stephen Whitmarsh, a neuroscientist and musician on our team, started the cloning process, transfers, and cultivation in Petri dishes on an agar-agar substrate.

Then Spora, an artist collective that works with fungi founded by Charlotte Janis and Roberto Dell'Orco, developed the mycelium by transferring it from Petri dishes to "mycelization" bags.

For several months, we cared for this mycelium. We learned to understand its fragile nature—an almost ephemeral structure. Finally, in the latest iterations of the installation, we had to grow mushrooms that were easier to cultivate, such as oyster mushrooms (*Pleurotus ostreatus*).

## Monitoring and Recording Mycelia

To define how to build our system, we conducted a state-of-the-art review of techniques for recording the action potentials of mycelium. We encountered a multitude of protocols.

For example, the first experiment I want to mention was conducted in 1976 by Dr. Slayman. He used a highly controlled environment in a room dedicated to recording, with a table isolating seismic vibrations and a glass microelectrode to measure the internal action potential of a cell. Slayman discovered, and I quote:

"[...] spontaneous voltage oscillations resembling action potentials in a fungus, the ascomycete *Neurospora crassa*. This action potential-like behavior is slow, lasts up to 1 minute or more, is associated with a strong increase in membrane conductance, and can have an amplitude of more than 175 mV. So far, no function has been identified for the voltage changes or the associated conductance changes."

The different types of voltage oscillations he observed included spontaneous Type A fluctuations—quasi-sinusoidal with an amplitude of 10–20 mV, persisting over intervals ranging from 10–15 minutes to 1 hour, with a constant period of 3–4 minutes—and Type B, similar but with shorter periods of 20–30 seconds. Types C and D were induced by blocking respiratory functions with cyanide.

In a second experiment conducted in 2021, Professors Adamatzky and Dehshibi set up a slightly less controlled environment. Temperature and humidity were stable, but there was no isolation from seismic vibrations. The recorded action potential was not intracellular; rather, subcutaneous electrodes were used to monitor a potential difference between several hyphae.

These different experiments from the state of the art show that the range of electrical activity in mycelium operates at very small scales—in the millivolt range—and within a frequency range that can vary from 0.5 to 5 Hz in Olsson and Hansson, down to 0.007 to 0.002 Hz in Adamatzky. This means that we can observe voltage pseudo-spikes five times per second down to once every 30 seconds, but also, and most often, one activity pseudo-spike every 2 to 8 minutes.

## To Adapt

For my installation, I was inspired by the protocol established by Adamatzky, which is easier and more suited to the creation of an artistic installation open to the public.

Some of our measurements are close to the state of the art—around 0.02 volts and below—while others fall into higher ranges, up to 1.64 volts. During this experiment, we hypothesized that the recorded signal corresponds to field potentials reflecting variations in electrical activity on the surface of specimens, rather than intracellular action potentials, as we did not have the necessary equipment for intracellular recording. It is also essential to recall that the recorded electrical voltages very likely contain other components, notably the accumulated voltage induced by the analog-to-digital converter used.

The observed temporality of this signal is very particular and very distant from that of humans. This continuous activity shows a very slow evolution with pseudo-activity peaks. We embraced these characteristics in our composition.

A technical tool—the EAVI board from the BBDMI project—is the interface that allowed us to digitize this voltage from the mycelium. This board, initially designed for humans, was adapted for the mycelium. Once digitized, we can use the signal to control musical processing.

#### **IV. Composing With**

As a composer, the musical challenge was to find strategies to compose with this signal. I wondered: What does it mean to compose with this mycelium—a being that has no intentionality that could be characterized as musical?

In this experiment, the signal was the starting point for compositional operations. Let me walk you through the process.

##### **Signal as Material and Control**

The mycelium signal is characterized by minimal variations: low-frequency oscillations with low amplitude. This signal served me both as sound material and as a control.

To build my sound material, I used the first recordings of the signal, which included instrumental noise. I worked on frequency representations. By applying the principle of sonographic synthesis, I shifted the partials of the sound to highlight the low frequencies characteristic of the recorded signal.

##### **Substrate and Sound Objects**

This material acted as a first sound substrate, which I then transformed using various processing techniques from the BBDMI and abclib libraries to construct a collection of objects that all inherit the properties of this substrate.

I also used this signal as a control to transform these different objects. The continuous signal was scaled and mapped to various processes. For example, the trajectories of certain sound objects are driven by this continuous signal: variations in signal amplitude can determine rotation speed. The higher the amplitude, the faster a sound source rotates.

##### **Emergence and Assembled Systems**

The collection of objects is then activated by the mycelium signal: the composed processes and the piece emerge from these multiple interactions. The piece offers a listening experience of sonic and

spatial morphologies, where emergent possibilities are driven by the indeterminacy of the mycelium. The mycelium transforms the perceived sonic milieu for humans.

### **Assembling: From Mycelium to Diffusion**

The *Mycelium Garden* installation has been presented in different configurations. I present here one of the latest iterations, performed in November 2023 during the Rencontres d'ArT'ec at Maison des Métallos in Paris.

This installation is an assemblage of multiple technologies, human expertise, and living mycelium. The diagram in the presentation illustrates the system connecting mycelium, machines, and humans: from mycelium to music, diffused through an immersive 3D sound system with 11 speakers in an ambisonic 3D configuration conceived by Paul Goutmann.

[At this point, I would show a video excerpt of the installation, approximately 30 seconds.]

Thus, the objects and installations developed in this project are conceived as foundations for reflection, aimed at rethinking the question of interspecies relationships—not as a process based on a shared culture and intentionality, but as a form of co-production of meaning through "adjustment of differences," following the concept developed by sociologist Dominique Guillo.

Indeed, in this project, the rhythm of the mycelium—its development, its growth cycle, its signal—guided each of our actions. This required adaptation and the ability to adjust, to reassess our expectations, to redefine the project itself, and to recognize that nothing is ever a given.

We thus developed a methodology shaped by our experiments. It led us to reflect on the notions of interface, translation, transduction, and scaling. In this work, we aimed to highlight all the stages of translation that allow us to access a composed auditory dimension of a mycelium/human relationship.

Additionally, this system invites us to question the aesthetic issues of forms that are generated automatically—or, in this case, guided by non-human processes—by revealing the fragmentation and dissolution of intentionality in such productions that synthesize and explore uncharted niches within our cultural spaces.

### **V. "Faire-Jardin" in Music: Conclusion**

In conclusion, these projects explored strategies that encourage attentiveness to the living through listening. Here, listening can become a sensitive modality and a vector in projects that involve dynamic interactions between humans and non-humans.

"*Faire-jardin*" in music, then, means co-creating with these different agents, designing devices as processes that build commons around attentive listening to the living.

In this way of composing, I try to foster emergent phenomena and seek to highlight singularities and diversity within an open and adaptive model. This is where interfaces such as our technological devices can help build these "adjustments" between different types of organic systems and machines, enabling their interconnection.

In this way of thinking about interaction, rather than a shared cultural, social, or morphological identity, it is the difference that becomes the driving force of the relationship. From the facilitation

of these interactions emerges a way to pay attention to the diversity of living as well as to musical morphologies.

Thank you for your attention.

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