



**HAL**  
open science

## Mycelium Garden

Diane Schuh

► **To cite this version:**

Diane Schuh. Mycelium Garden. ISEA 2023 - Symbiosis - 28ème Symposium International de la création numérique, ISEA international; Ecole Nationale Supérieure des Arts Décoratifs; Le Cube Garges; Forum des Images, May 2023, Paris, France. hal-04109049

**HAL Id: hal-04109049**

**<https://hal.science/hal-04109049>**

Submitted on 29 May 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Mycelium Garden

Schuh Diane

CICM/Musidanse-EA1572/EDESTA / EUR ArTec Université Paris Lumière / MSH Paris Nord UAR3258

Saint-Denis, France

[schuh.diane@gmail.com](mailto:schuh.diane@gmail.com)

## Abstract

This project aims to take into account the singularity of a mycelium network in a mode of interaction with humans that is based on listening and attention. We are building a setup for the development of sensitive interactions with the mycelium, an organism that facilitates symbioses, through an interpretation of the specificity of its electrical expressions connected to our human musical world. To build this interaction we will develop AI models to map the behavior of the mycelium, co-compose sounds with the recorded and classified electrical variations and finally build an interspecific and sensitive relationship. This model will attempt to retain the dimension of otherness in sensory interaction. It will share an experimental process that will allow us to enter into a relationship with a non-human organism, to observe its behavior and to adjust our behavior in interaction with it. Thus questioning the notions of intelligence and adaptation in a three-agent human/AI/Mycelium compositional process. What would be the mycelium's intelligence compared to that of the human musician and that of the artificial intelligence: what do we mean by this? This installation addresses the importance of recognizing the otherness of non-human beings in the ecological project of caring for the living.

## Keywords

Mycelium, Symbiosis, Deep Learning, Artificial Intelligence, Electroacoustic Music, Music Composition, Sound Installation, Multimedia Installation, Cloning, Interspecific Interactions.

## Introduction

Throughout a research-creation process, this installation exposes an interspecific exploration and a sensitive rendering of a communication and co-composition between three agents (Mycelium/AI/human). These agents will interact in a relationship that does not seek to share an identity but is based on the notion of adjusting differences and acknowledging otherness.

This installation deals with the importance of recognizing the otherness of non-human and non-animal beings in the ecological project by facilitating the conditions for the emergence of a symbiotic dynamic. [1]

## Listening to the 'music' of living cells

Since 1873 we have known that plant cells conduct electrical signals. Burdon-Sanderson was the first to identify the Action Potential (AP) in plants, which is activated by mechanically induced movements, as in *Dionaea*. [2]

Musicians and sound artists have used these electrical properties to build devices based on electrical signal transduction systems. [3] [4] [5]

In the framework of the ANR BBDMI (<https://bbdmi.nakala.fr/>), researchers from CICM and ICM at MSH Paris Nord developed prototypes in 2022 to measure electrical signals from the muscle and brain (EMG and EEG) using electrodes, amplifiers and analog-to-digital converters to make music with these signals. Through this project we will test how we can build on this modular technology to the present installation in order to monitor the AP of the mycelium.

## Mycelium and fungi, signal and symbiotic networks

The mycelium is a vegetative underground organism whose fruiting bodies are the fungi. In the case of mycorrhizal fungi, the network can then connect several root systems of sometimes different plants. [6] [1] A symbiosis is observed: a sustainable coexistence between two organisms whose interactions are mutually beneficial. [1]

Scientists have revealed Action Potential in fungi and mycelium networks. In 1995 Olsson and Hansson measured electrical signals in the mycelium of *Neurospora crassa*. [7] Dehshibi and Adamatzky discovered by multichannel analysis the complexity of signal transmission systems in the network mycelium of *Pleurotus ostreatus*. [8] This extreme diversity could then be compared to the complexity of human languages, even surpassing it in some cases. [9]

## Recognising the otherness of living beings: inventing ways of interacting with non-human organic beings

### Beyond anthropomorphism

To date, we are not aware of any research into musical composition based on the electrical signals produced by a mycelium network that takes into account the complexity highlighted by Dehshibi and Adamatzky. Moreover, these approaches often fall into the category of anthropomorphism, or even anthropocentrism, of a personification of non-human life.

Our project seeks to develop a device for sensitive and specific interaction modalities with the mycelium and its fruiting bodies, through an interpretation of the singularity of their electrical expressions. [10] [8]

### Accounting for otherness

Our project aims to take into account the otherness, singularity and multiplicity of a mycelium network in a mode of interaction with humans that is based on listening and attention. The aim is to make audible the complex and invisible dimensions of these organic beings that are often perceived as inert.

We will invent a model of interaction that facilitates human sensitivity to others. This model will not seek to induce an anthropomorphic empathy reaction but will try to keep the dimension of otherness in the non-verbal sensory interaction, thus creating a new sound space understood as a hybridization of symbiotic individuations, which will give us the opportunity to examine and deepen the notion of symbiotic individuation in this present work.

### Methodology

The project involves building the conditions for the emergence of a mycelium network from a strain harvested in the MSH Paris Nord garden while adapting a technology designed for humans to a non-animal, non-plant living organism, and finding adequate mapping of their AP through AI, to produce a music composition that invites to listening and being attentive to the living.

### Paying attention to the living in a mycelium garden

The core of the project is the creation of an interactive sound installation in co-creation with a network of mycelium whose emergence, development and life conditions will have been organized by humans.



Figure 1. *Agaricus arvensis*, mushroom from which we are currently cloning the mycelium. photo ©Diane Schuh.

The development of the mycelium garden is planned over an eight month period. This work will be carried out

in three phases. The research phase includes the search for mycelium in the MSH garden, feasibility, extraction and cloning in sterile Petri dishes. The second phase includes the cultivation in sterile jars and the first multiplication of the mycelium. Finally, the last phase includes the multiplication of the mycelium in 3 steps (from 0.1 m<sup>3</sup> to 1m<sup>3</sup> necessary for the size of the installation) as well as the transport of the mycelium from the laboratory to the exhibition room, the assembly of the substrate and the scenography structure. During these 8 months, we are accompanied by Spora Studio as a consultant. They will provide advice and technical monitoring of the organic part of the installation.

We are currently in the first phase. We started by identifying and collecting different mushrooms present in the garden of the MSH Paris Nord. The *Agaricus arvensis* mushroom we found adequate (Fig.1) has started to be cloned in Petri dishes. In this first step we had a success of 1 from 6 growing strains (Fig2.). The mycelium is currently growing at a steady pace, comforting us in our first hypothesis i.e. the feasibility of cloning a mushroom extracted from the MSH Paris Nord garden.

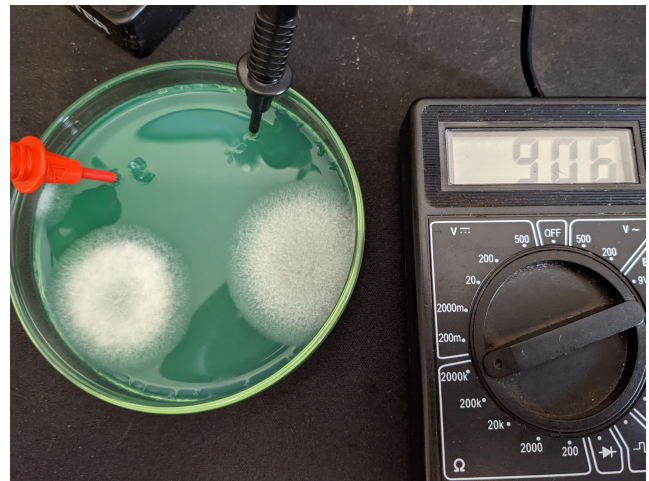


Figure 2. The successful mycelium strain. Monitoring the conductivity of the substrate before measuring the AP of the mycelium. photo ©Stephen Whitmarsh.

We intend to be at phase 2 during the ISEA Symposium. That means that we will be able to present several strains of mycelium which would have formed emergent networks that we will be able to monitor for building the AI model, the mapping and the music composition.

### Building the interface and architecture mycelium/sound

We will build on the tested and proven technologies and expertise of the ANR BBDMI project to develop the sound mapping of the mycelium activity to the installation. Using this project's small equipment, including AEVI cards and electrode samples, we will test the feasibility with the mycelium network. [12] The EAVI board has 4 inputs that are treated by an analog to digital converter (ADC) with a good signal to noise (S/N) rate and high amplification. The

ADC module on the board can be seen as an operational amplifier with independent reference. That means that we can get 4 bipolar independent measures or connect all the references together and get the 4 signals in reference to one only point. The board streams the raw input signal at a sampling rate of 8Khz by USB with an optical isolation module between the board and the computer. We will soon test the Bluetooth version with data streamed as MIDI. For this project we will use two EAVI boards allowing us to monitor 8 nodes of the mycelium network and thus accounting for the diversity of its electric expression.

At the moment of writing this article we are in the preparation of measuring the electrical activity of the mycelium. We expect to get a 5mv signal in some circumstances or even higher voltages.

### **Building cross-species communications using AI**

In the framework of this experimental research we will test different processes in building an interspecies communication setup. At this time we are starting an observation phase. To establish an interspecific relationship with the mycelium we must observe and record the mycelium's activity. In this phase we will record and analyze the Action Potential of the mycelium. An AI with a machine learning model based on unsupervised learning will help us categorize and classify different patterns of the mycelium's electrical activity. We will be able to determine the time scale and the frequency of these patterns emerging from the activity.

We will use AI processes to explore creative mapping that allows the mycelium to interact with the different sound engines composed. These models include linear regressive interpolations and reinforcement learning models. This machine learning category allows mappings to adapt in real time. [11] We believe the adaptability of this model will account more accurately for the specificity and the diversity of the mycelium's networks activities. In examining these possibilities we will attempt to examine the notion of symbiosis but also the ontology of AI.

After this research process, we will set-up the installation. The sounds co-composed with the AI will be modulated by the activity of the mycelium network. Is this setup possible in real time given the slow activity of the mycelium is an hypothesis to be tested at this phase of the project. The research and co-composition phases will allow us to understand the different types of behaviors and interactions in a mycelium/AI/human relationship. This phase will allow experimentation and analysis of the different types of behavior depending on the organism. Can

### **References**

- [1] Selosse Marc-André, *La symbiose: structures et fonctions, rôle écologique et évolutif* (Paris, France: Vuibert, 2000).
- [2] Fromm Jörg, Lautner Silke, "Electrical signals and their physiological significance in plants", *Plant, Cell & Environment*, vol. 30, n° 3 (2007): 249-257.

we talk here about intelligence or adaptation? We will find strategies to account for the diversity, especially of the functional diversity of the mycelium.

### **Work in progress presentation**

The MSH Paris Nord will host the project in its premises, within the framework of ISEA 2023. During this period of time we will present a progress review. We will expose a first modality of presentation for the interactive sound installation. Several Petri dishes with mycelium cloned from *Agaricus arvensis* and several glass jars with plants and their mycorrhizal networks transplanted from the MSH Paris Nord garden will constitute our Mycelium Garden. These organisms will be connected by electrodes to two EAVI boards, resulting in eight PA monitoring channels. The activity of these eight channels will be interpreted by the AI model mapped according to the interaction between the mycelium and the composer during the architecture composition phase. We will be able to hear the first results of the sound installation: the co-composition human/mycelium network.

The objects and set-up developed in this project will serve to rethink the question of interspecies communication, conceived not as a process based on a common culture and intentionality but as a form of co-production of meaning by "adjusting differences". [13] They will also invite to question the aesthetic stakes of forms generated automatically or, in this case, guided by non-human processes, showing the fragmentation and dissolution of intentionality in this type of productions, which synthesize and explore unexplored niches of our cultural spaces. By integrating AI design in this context, it is also ultimately a question of seeking to compare intelligence: what do we mean when we talk about intelligence? What would be the mycelium's intelligence or adaptivity compared to that of the human musician and that of the artificial intelligence: what do we mean by this?

### **Acknowledgements**

We acknowledge our funding bodies: EUR ArTec and MSH Paris Nord.

We acknowledge the work of the team gathered around this project: Charlotte Janis and Roberto dell'Orco from Spora Studio ; Anne Sèdes, Alain Bonardi and David Fierro from the CICM ; Guillaume Pereux and Julien Schuh from the CSLF Nanterre ; Stephen Whitmarsh from ICM ; Hugo Scurto from ArTec.

- [3] Darren Moore, Guy Ben-Ary, Andrew Fitch, Nathan Thompson, Douglas Bakkum, Stuart Hodgetts & Amanda Morris "cellF: a neuron-driven music synthesiser for real-time performance", *International Journal of Performance Arts and Digital Media* 12:1, (2016): 31-43.
- [4] Garcia Leslie, "INTERSPECIFICS", accessed November 29, 2022, <https://github.com/interspecifics>.

- [5] Agapea Saša Spačal, “Infrastructures for Each Other”, accessed November 29, 2022, <https://www.agapea.si/en/projects/infrastructures-for-each-other>.
- [6] Miyachi Shingo et al., “Large-scale genome sequencing of mycorrhizal fungi provides insights into the early evolution of symbiotic traits”, *Nature Communications*, vol. 11, n° 1, (2020): 5125.
- [7] Olsson Stefan, Hansson Bill, “Action Potential-Like Activity Found in Fungal Mycelia Is Sensitive to Stimulation”, *Naturwissenschaften*, vol. 82, (1995): 30-31.
- [8] Adamatzky Andrew, “On spiking behaviour of oyster fungi *Pleurotus djamor*”, *Scientific Reports*, vol. 8, n° 1, (2018): 7873.
- [9] Dehshibi Mohammad Mahdi, Adamatzky Andrew, “Electrical activity of fungi: Spikes detection and complexity analysis”, *Biosystems*, vol. 203, (2021): 104373.
- [10] Berbara Ricardo, “Electrical currents associated with arbuscular mycorrhizal interactions”, *New Phytologist*, vol. 129, n°3, (1995): 433-438.
- [11] Radford Alec et al., “Learning Transferable Visual Models From Natural Language Supervision”, *arXiv*, (2021), Accessed December 3, 2022, <http://arxiv.org/abs/2103.00020>.
- [12] Scurto Hugo, “Designing With Machine Learning for Interactive Music Dispositifs,” (Ph.D. diss. Sorbonne université, 2019).
- [13] Di Donato Balandino et al., “EAVI EMG board”, (2019).
- [14] Guillo Dominique, *Les fondements oubliés de la culture: une approche écologique* (Paris, France: Éditions du Seuil, 2019).

## Author Biography

Diane Schuh is an experimental landscape-architect, a musician, a composer and an artist. Her PhD thesis, under EDESTA doctoral contract entitled "Symbiosis, milieux, gardens in motion: what the gardener does to music" studies the transfer of models and methods from the garden to composition. Her research explores the pedagogical and operational potential of the symbiosis model in the development of compositional and listening set-ups that invite and encourage attention to the living.