EM FOCO

WHEN CONSTRAINTS OF EMBODIED COGNITION BECOME POROUS: PERFORMANCES OF SENSORY INTERACTIVITY IN DESIGN

QUANDO AS LIMITAÇÕES DA COGNIÇÃO CORPORIFICADA SE TORNAM POROSAS: PERFORMANCES DE INTERATIVIDADE SENSORIAL NO DESIGN

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ABSTRACT:

In design processes, the concept of the embodied mind can be mobilized to consider the ways in which our bodily experiences and actions affect our perception of space. With this focus in mind, what happens when human–environment interactivity ceases to be a utilitarian exchange between an evolving, sensing body and a predetermined object, but becomes conductive, generative, adaptive, and learns to grow? Perhaps in that moment of interaction and touch the space affects embodied action and perception in turn? These questions were pursued in a series of Practice-as-Research experiments by advanced designers in training from four disciplines at the University of Calgary: technical theatre, computational media and design, architecture, and sonic arts. The aim of the group's work is to make design experientially accessible as an affective process with the ability to render porous the bodily constraints of human cognition. Here, the designers share insights, ideas, and obstacles from their collaborative research process.

Keywords:
Interactive design. Embodied cognition. Agent based modelling. Tangible computing. Collaborative creation.

RESUMO:

Nos processos de design, o conceito de mente corporificada pode ser mobilizado para considerar as maneiras pelas quais nossas experiências e ações corporais afetam nossa percepção do espaço. Com este foco em mente, o que acontece quando a interatividade humano-ambiente deixa de ser uma troca utilitária entre um corpo evolutivo, sensível e um objeto predeterminado, mas se torna condutor, gerador, adaptável e aprende a crescer? Talvez nesse momento de interação e toque, o espaço, por sua vez, afete a ação e a percepção corporificada? Essas questões foram perseguidas em uma série de experimentos de prática-como-pesquisa por designers avançados em treinamento de quatro disciplinas na Universidade de Calgary: técnica em teatro, mídia computacional e design, arquitetura e artes sonoras. O objetivo do trabalho do grupo é tornar o design experiencialmente acessível como um processo afetivo com a capacidade de tornar porosas as restrições corporais da cognição humana. Aqui, os designers compartilham insights, ideias e obstáculos de seu processo de pesquisa colaborativa.

Palavras-chave:
Design. Interação performativa. Cognição corporificada. Modelagem baseada em agentes. Computação tangível. Criação colaborativa.

INTRODUCTION

In design processes, the concept of the embodied mind can be mobilized to consider the ways in which our bodily experiences and actions affect our perception of space. With this focus in mind, what happens if the responsiveness and agency of the contemporary technology-mediated environment is made visible and enhanced through design choices? What happens when human–environment interactivity ceases to be a utilitarian exchange between an evolving, sensing body and a predetermined object, but becomes conductive, generative, adaptive, and learns to grow? Perhaps in that moment of interaction and touch the space affects embodied action and perception in turn?

These questions were pursued in a series of Practice-as-Research experiments by advanced designers in training from four distinct disciplines at the University of Calgary in Canada: Bianca Guimarães de Manuel from technical theatre, Gabriele Kuzabaviciute and Roxane Fallah from computational media and design and architecture, and Abdullah Safa Soydan from sonic arts. Working collaboratively across these disciplines from January to April 2017, the group developed interactive works with a focus on physical computing, tactile surfaces, and body movement, using the full range of organic, material, and technological media available to them. This work was supervised by Pil Hansen from dance and drama and Vera Parlac from environmental design and architecture. The both fundamental and utopian

aim of the group's work was (and is) to make design experientially accessible as an affective process with the ability to render porous the bodily constraints of human cognition. In this process the physical and sonic environments are manipulated to test the porosity of their boundaries in relation to human experience. The group regards their Practice-as-Research process as the first of multiple iterative engagements with this objective as a generator of new creation. Here, they share insights yielded from the conceptual, material, and performative work completed in this first iteration – insights that both reflect the pressures of design expectations and set the group off on a path towards their utopia.

EMBODIED INTERACTIVITY: THEORETICAL CONCEPTS IN PLAY

Interactivity is understood differently in each group member's discipline. This difference is productive.

To the architect, the ability of a computationally animated architectural space to receive and respond to human input is a base-level form of interaction. At this level, interactivity is a dialogue between a human being and a computer program that governs the behaviour of the object or environment. Developing a more complex approach to interactivity, the possibility of continued and unscripted "conversation" between the user and the space is pursued. Such an environment does not only sense and respond, but also perceives and acts. This advancement is captured in the concept of *anticipated architecture* and realized through complex behavioural and informational systems designed to both receive input and generate input through algorithmic mutations – to learn to grow[1] (PARISI, 2013; PARLAC, 2015).

When designing an anticipatory space with such computational capacity, the designer works with a range of environmental and newly constructed materials which are organic, synthetic, electronic, etc. In the field of computational media and design, the concept of *material integration* speaks to an artistic and experiential

1 Early versions of this concept were developed in the late 1960s and early 1970s by Cedric Price (Fun Palace), Nicholas Negroponte (Soft Architecture Machines), and Chuck Eastman (concept of "adaptive-conditional architecture"). These projects began to explore "intelligence" and the programmability of architecture's processes and spaces in order to form a two-way relationship between spaces and users (Parlac 209). A truly responsive environment would enter into a "conversation" with its users and allow them to become participants (Fox and Kemp 209).

process of integrating such materials that reduces and ideally eliminates boundaries and potentially renders non-electronic materials conductive. As Reza Negarestani (2011) argues, such an experiential process is achieved by becoming complicit, by partnering up with the material of artistic production and recognizing the influence of the material's autonomy on the design. Robles and Wiberg (2010, p. 139-140) suggest that a focus on texture (the feel or consistency of a surface) can help integrate technical and organic materials through tactile complicity and engagement, because "it is when elements come together as textures that we can read, interact, and relate with the physical world".

When boundaries are thus softened and distinctions between the electronic and the non-electronic are no longer clear, expectations of daily or artistic performance that derive from conventions are no longer satisfied, and new "contracts" of audience experience and participation need to be established. As discussed by Ireti Olowe, Giulio Moro, and Mathieu Barthet (2016), sonic artists who build instruments through computer programming and various interfaces come up against the audience expectation of being able to see how interaction between musician and instrument produce sound. The gap between this expectation and sonic arts widens with the advances of material integration and instruments that, like anticipated architecture, are generative. To bridge this gap the field is developing strategies of performance that invite audiences to perceptually investigate and gradually learn principles of sound generation (OLOWE et al., 2016).

In the fields of theatre, performance art, and dance the subject of audience expectations is considered central to interactivity. Participatory stage work softens boundaries between the fictional and the real, between representational acts and designs that are recognizable as fiction and those that cause irreversible change and affect performers, participating audiences, and environments alike. Key to this shift, however, is the nature of the invitation to participate that is extended implicitly by the artwork, including the artwork's dramaturgical ability to "play" with the expectations, embodied praxis, and memories of participants. With the concept of invitation comes a question about how design solicits interaction from individuals who bring a wide range of perceptual, cognitive, and fully embodied

knowledge to every new relationship. What are the risks involved for the artwork and the participants? (WHITE, 2013).

Within interactive installations that solicit sensory and embodied responses, the performance that audiences witness and perform is neither solicited through a fictional situation nor a characterization that makes it meaningful. Rather, the installation invites functional interaction and exploration of material objects and spaces that evolve through various forms of feedback as well as through the participant-performer's gradually developing understanding of the installation's interfaces and responsivity. As participants explore such an interaction, multiple layers of performance take place. These layers are described by dance scholar Sarah Rubidge (2009, p. 371):

> In a choreographic digital interactive installation designed for audience interaction, visitors tend to both 'perform' the installation and perform *in* the installation. The participants' behaviour in these instances lies somewhere in between; that is, the performance of an action for functional reasons (in this case action intended to trigger the interactive system, and thus 'perform' the installation), the performance of an action being attentive to the nuances of the action itself (and thus perform *in* the installation), and action as performance to be viewed.

The additional understanding that the concept of choreographic interaction brings to our theoretical framework is thus that the performance of movement is affected in equal measures by the installation, the participants' self-consciousness, and their tendency to witness each other.

This anticipation of layers of movement performance can productively be expanded with consideration of potential performative acts in and of the space; that is, acts that iteratively constitute or perhaps even slightly adapt our reality. (BUTLER, 1993). What do the invitation, material integration, and anticipatory generation of the installation do? How do these qualities affect the participant? Might they constitute or perhaps iteratively adapt the participants' embodied

knowledge of the space, the technology, and their own movement? How, in turn, does the participation act on the installation, on what it can become?

Such performative effects are hard to read as they often remain implicit. Indeed, several of them would be established in the participants' perceptual and cognitive experiences and not necessarily be expressed in the observable layers of performance. Concepts of embodied and distributed cognition can be used to better qualify speculations about such implicit effects of interaction.

Embodied cognition refers to the cognitive coupling of motor action and perception with consequences for learning and memory.

> Perception is never independent of action (Schütz-Bosbach and Prinz 2007), it is always shaped by the body and its spatiotemporal conditions. Therefore, memory in its most immediate form is embodied and situated in the world via our bodily self (Glenberg 1997). ... Most aspects of memory are considered constructive in the sense that memories are not stored as whole entities ready for recall, but are flexible and adaptive in ways that we rarely experience consciously. Action-based perception is already shaped by our experiences and provides us with new stimuli that elicit the reconstruction of memories (HANSEN; BLÄSING, 2017 , p. 10).

It follows from the notion that when participants perceive an interactive space or installation soliciting movement, their perception is already shaped by past sensorimotor experiences. When adjusting and learning how to interact in response to the feedback and qualities of the specific space such sensorimotor memory and knowledge may become adapted. This reconstruction and adaptation of the memory that forms the very precondition of movement can be understood as an irreversible and performative effect.

Cognition is not only embodied, it is also situated in and distributed to our environment (MICHAELIAN; SUTTON, 2013). Each environment contains a specific and often recognizable set of clues that governs our sensorimotor interaction. For example, a kitchen is set up to aid a series of specific tasks, which we learn,

understand, remember, and perform in response to the constraints of this setup. The same is true about the task-worlds of a theatre, a gallery, or a social unit. We are rarely responding to open possibilities from our individual memories alone; the environment provides specific constraints that allow us to function accordingly (HANSEN; BLÄSING, 2017, p. 23-24; TRIBBLE, 2017, p. 99).

The softening of boundaries involved in material integration, the ambiguous agency of anticipated architecture, and the renegotiated contract of performance solicited by an invitation to interact all reduce, alter, or manipulate the task-world of the installation space and its constraints. Between the reconstruction of embodied memory and this softening of cognitive constraints it is indeed possible that an installation can affect how participants act and perceive. In other words, it is possible to reach the utopian goal of the design group that was first mentioned in our introduction.

MATERIAL EXPLORATIONS OF INTERACTIVITY AND THEIR PERFORMATIVE POTENTIAL

DESIGN AND PRACTICE-AS-RESEARCH PROCESS

The process of progression from a theoretical framework to a material, interactive installation typically involves three stages: the development of clear concepts that are externalized in drawings and models, the construction of a large-scale prototype, and the building of a full-scale installation. Although this group of designers did proceed through comparable steps, they were working under three conditions that significantly altered the utility of linear progression from concept to realization, and that called for a process more aligned to the iterative experiments of a Practice-as-Research (PaR) paradigm.

Two influential authors on the subject of PaR, Robin Nelson and Baz Kershaw, who rarely agree on much, share the understanding that PaR knowledge *emerges* in the creative making and exploration of the performing arts. As Hansen discusses in a recent article, this epistemology is often:

> manifested in research projects that evolve iteratively rather than by pursuing hypotheses systematically through fully pre-planned steps. The knowledge produced emerges in the meeting between the artists' skilled and often procedural 'know how' and the new challenge, object, or environment this implicit knowledge is applied to. It depends on creative openness towards exploration of the possibilities this meeting brings about, as well as attention to and articulation of the learning curves and practical attempts to overcome boundaries that are involved in the pursuit of this potential (HANSEN, 2017, p. 18).

The first of the three conditions indicated above is the fact that the group was not working with a clear theoretical concept, but rather with a matrix of interwoven concepts that affect each other. The second condition was also a consequence of the theoretical framework. The realization of this framework could not be tested in conventional forms of visual externalization (models, drawings, algorithms) because it depended on sensorimotor and performative feedback. The embodied language and mental imaging involved as modes of understanding in model-building were not sufficient to experience how the design invited interaction or affected the constraints of embodied cognition. Design prototypes had to be built and interacted with by participants. The third condition was that of designing through interdisciplinary collaboration between designers with four different discipline-specific approaches and four native languages and cultural backgrounds.

In the following section, the group members report on the work done and insights arrived at in five PaR experiments. They also offer ideas for how these insights can feed into a next research iteration within the parametres set by the three aforementioned conditions.

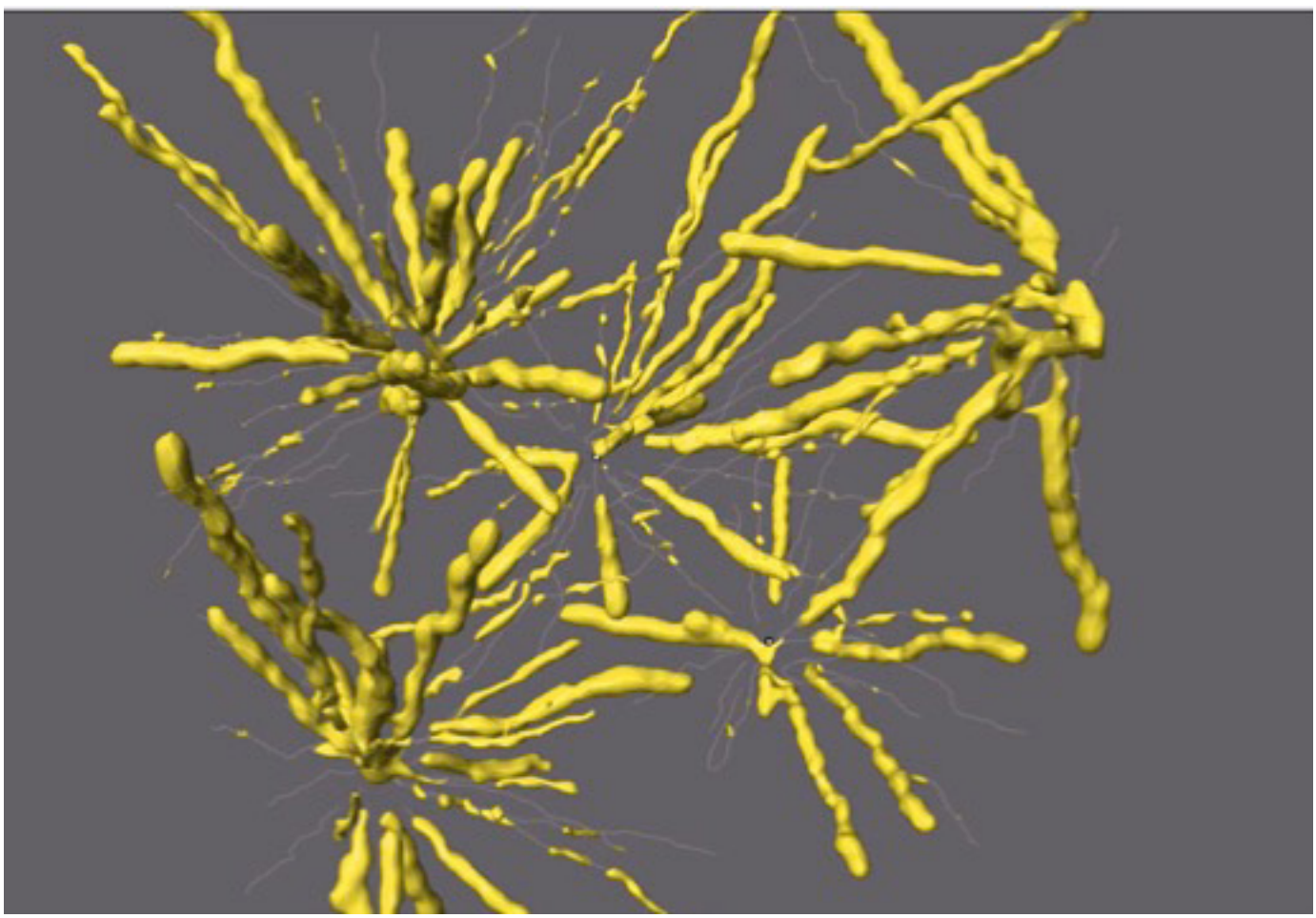

Figure 1: Agent-based simulation of slime mould growth. Photo: Roxane Fallah, 2017.

EXPERIMENTS

A consequence of action-perception coupling is that embodied cognition and action that extend to the environment are limited to the aspects of our surroundings that we attend to and can perceive. Yet, the majority of our environment is not readily perceivable. Its ability to grow and decay as well as its many chemical, electronic, and sonic processes rarely register unless they reach extremes.

Addressing this limitation in collaboration with Soydan, Fallah was interested in whether the behavioural rules and emergent patterns of natural microorganisms in our environment can be applied to a generative design process, capable of producing organic forms. Fallah introduced the observation that in the natural world shape and matter are structured thorough growth and adaptation. For example, a slime mould cell perceives its environment as a self-learning unit, learns from it by repositioning itself, and takes action accordingly and adaptively. Fallah developed an algorithm for computational, agent-based design, which produced a virtual simulation of the growth patterns slime mould develops over time when moving towards attraction points such as food sources – for an introduction to agent-based design see Achten (2014). The velocity and coordinates of this simulation were exported to Soydan, who used them to design corresponding sounds. Working with multiple channels of sound, Soydan used eight speakers to represent eight agents (i.e. simulated slime mould cells). The sound for each speaker was played back at varying speeds, drawn from the extracted data. In performance, this sound design was synced to a projected three-dimensional representation of the slime mould growth and the two became merged in the audience's perception. The main interaction of the installation was thus created through transferring mathematical and generative principles from the biological, through the visual, and to the sonic modes of expression, and this interaction was extended through audience perception. Beyond perception, this experiment did not receive embodied input from participants; the "body" explored was primarily environmental.

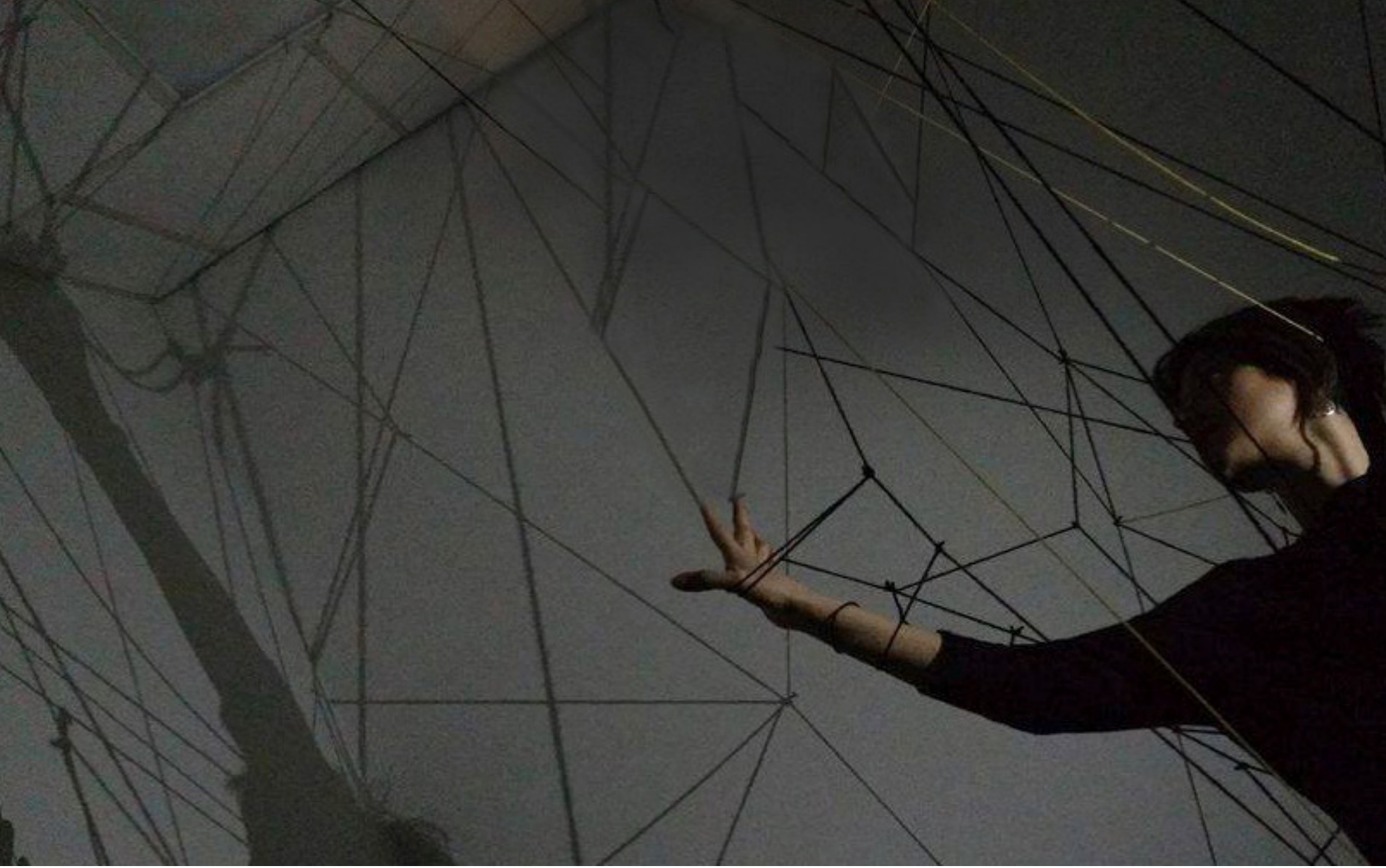

Figure 2: Web installation. Photo: Gabriele Kuzabaviciute, 2017.

Continuing to work on rarely noticed aspects of our environment through materials that render their affect or growth visible, audible, and tangible, Manuel and Fallah aimed to soften the boundaries of a small, white office space.

As illustrated in Figure 2, a web of strings tied in knots that rendered it responsive to touch, was attached to the built environment and a central chair. Projected light produced shadows that were similar to the strings in thickness and colour. The points of attachment in the space became a hard-to-discern boundary between the material web and its projection on the walls. Because of this softened boundary participants experienced perceptual ambiguity. Through the performativity of participants' perception and physical exploration of the space, material integration of the physical and virtual actualities was produced.

The next two experiments we have chosen to discuss here concentrated on the responsive behaviours of a physical, architectural environment and interfaces between haptic and sonic qualities.

Fallah and Kuzabaviciute designed interlocking, three-dimensional printed parts with an organic shape that, when connected and manipulated by a small engine, became flexible and able to change form. A sensor attached to the engine was triggered by a loud sound stimulus: clapping. While the experiment did change our perception of an otherwise inert space, turning it into a responsive and reflexive gesture, both of the interactive gestures solicited by this work (clapping and moving) were experienced by the team as too limited to set into motion a generative, interactive feedback process. Important questions were raised about how an interface can become available for a wider range of engagements and interactions. Perhaps interfaces need to be integrated materially through exploration of organic surface textures.

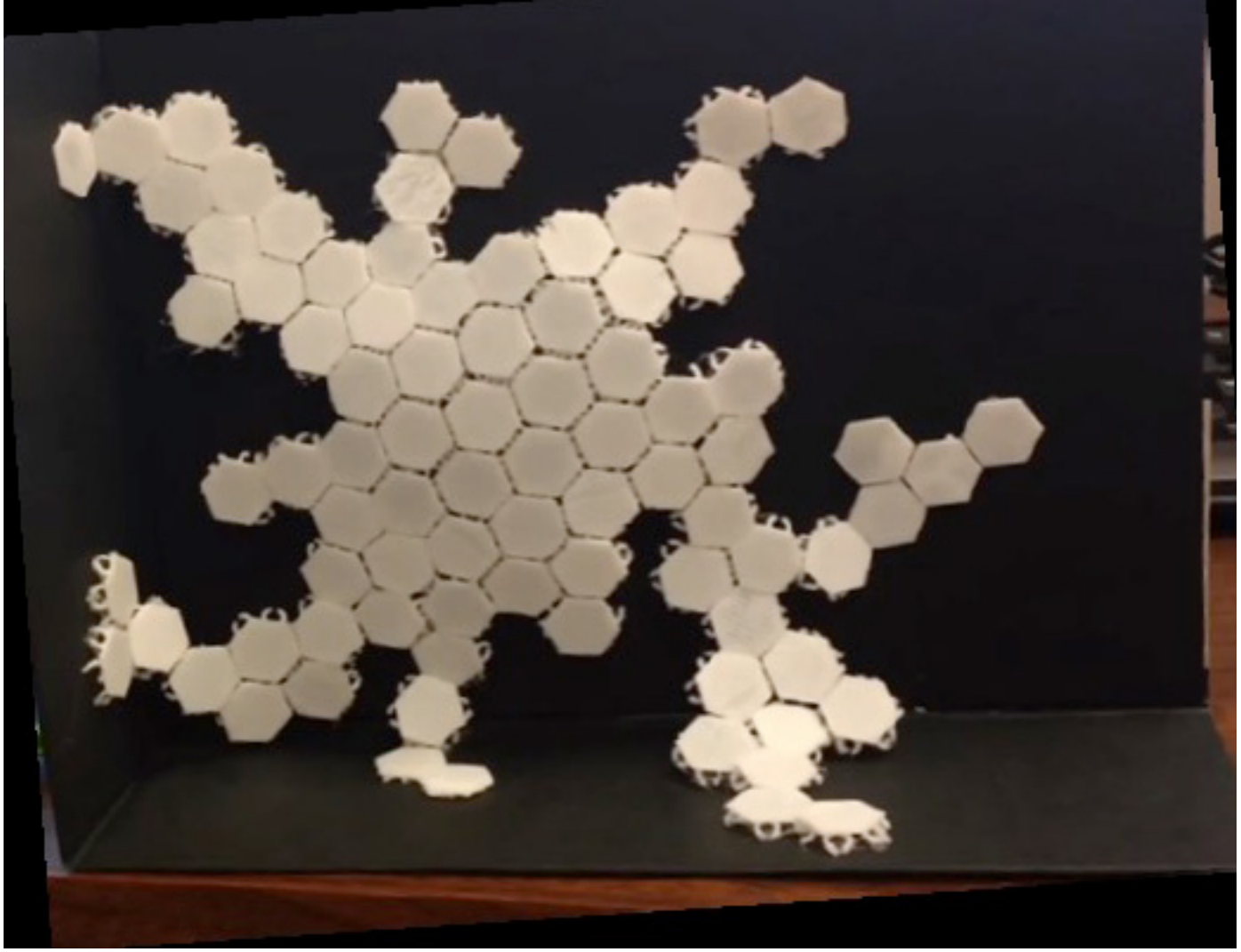

Figure 3: Dynamic surface. Photo: Gabriele Kuzabaviciute, 2017.

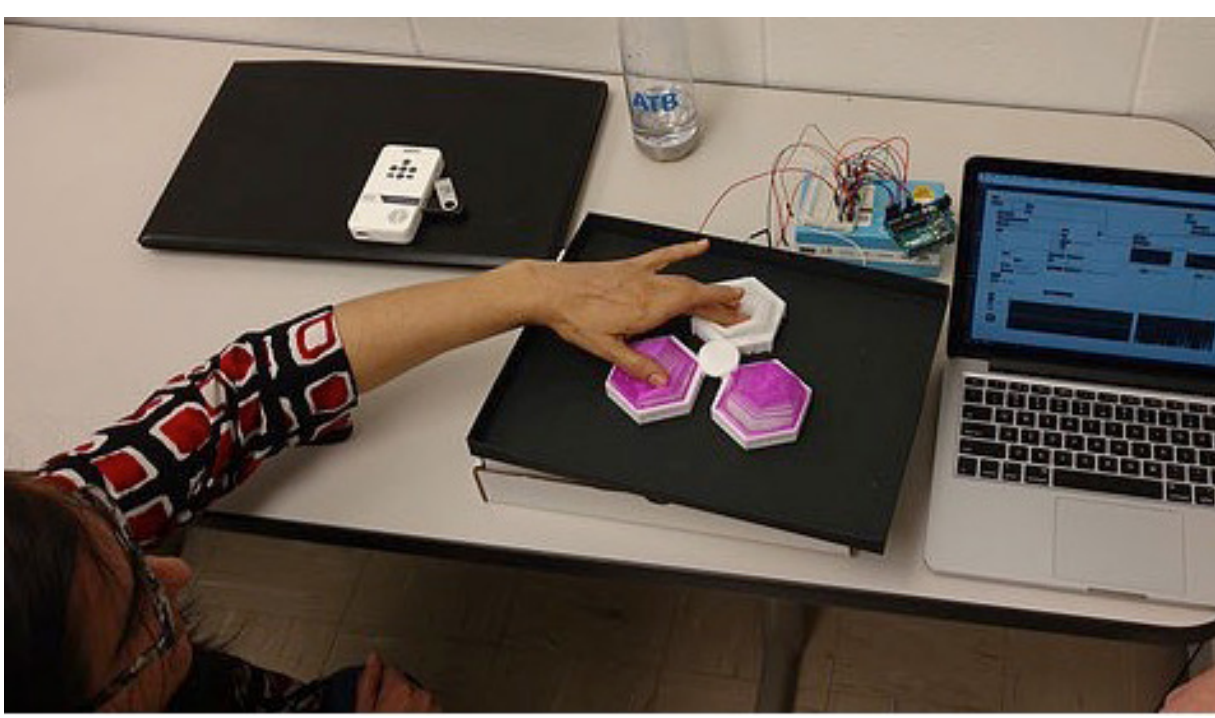

Figure 4: Textual touch-synthesizer. Photo: Gabriele Kuzabaviciute, 2017.

Kuzabaviciute and Soydan created a tactile instrument – or "touch-synthesizer" – in response to these questions. Driven by an interest in texture and its effect on participants' interaction, they explored the ways in which certain qualities of touch, such as speed, direction, and force, can influence the expressiveness of a sound-producing interface. In more technical terms, they used three force sensors to control three different parametres of an FM synthesizer: oscillator frequency, note length, and harmonicity value. The data from the sensors was channelled through an Arduino (an electronic board based on easy-to-use hardware and software), which was wired to a sound-producing program on a laptop computer. The tactile interface of the instrument was a spiral created in plastic and stuffed with polyester that contracts and expands in response to touch. These material textures reflected sonic textures, which became more complex in response to the pressure of touch. The interface was not fully integrated materially in the environment, but it was capable of stimulating intimate multi-sensory feedback and invited a wide range of interaction. This interaction was in part informed by the participants' intellectual understanding of the device's physical properties and in part informed by more implicit embodied memories triggered by the qualities of touch experienced.

The last experiment we have chosen to present here was created by Manuel and Soydan on the subject of the invitation to interact. They considered the range of expectations, knowledge, and memories that audiences might bring to an interactive installation and aimed to develop a sonic interface and environment that would encourage the audience to play with these components. Soydan created a patch with Max/MSP (a language to create interactive programs, especially focusing on audio and visuals), which enabled the participants to trigger and change the sound levels of individual soundscape samples. The sounds (rain, city rumble, forest, etc.) were predominantly recognizable as deriving from specific environments. During the presentation of the experiment, an iPad was given to the participants. They were not offered instructions or explanation and the simplistically designed interface on the iPad revealed nothing about the sounds.

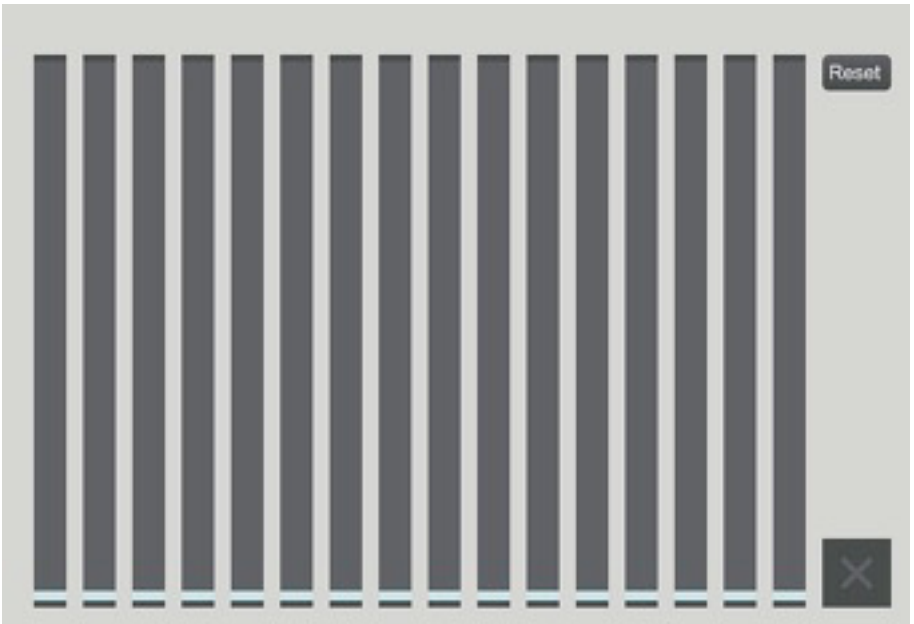

Figure 5: Graphical User Interface on iPad for the experiment. Image: Abdullah S. Soydan, 2017.

The idea behind this choice was to enhance the participants' attention to and awareness of the sound produced as a necessary part of the learning curve they underwent while exploring sound combinations and figuring out the instrument. Manuel and Soydan hypothesized that the absence of explanations for individual sounds would make participants attend more to the sonic effect of their interaction and thus also raise their awareness of the changes produced. Some participants expressed that this immersive soundscape evoked feelings connected with places familiar to them, places where they had walked, hung out, and felt the moisture in the air. Thus, the invitation to play with individual soundscape sounds may trigger embodied, multi-sensory memories, which in turn constrain the participants' choices of interaction. Manuel is particularly interested in this dynamic because of the fact that the soundscapes that are created and feel familiar are not a complete match with the memories. The play involved in manipulating soundscapes and the blurring of differences may adapt the reconstructed memory.

Within and between these interdisciplinary experiments several of the selected theoretical concepts were realized and explored in rich ways. An invitation to interact was extended through the playful creation and adaptation of soundscapes

that, at times, resonated with the participants' auditory and embodied memories. The learning curve involved in this play and the negotiation between several participants that also occurred ensured that the installation was not merely confirming or reconstructing autobiographical memory. Rather, it likely adapted and constructed memory performatively and within the integration of the sonic and cognitive processes at work.

Interfaces for interaction that were triggered by the bodily actions of touch and clapping were created and empowered to render flexible and responsive a built architecture, or the sonic qualities of a space, potentially extending the reach of human perception and action so central to the embodiment thesis. Through further development, these interfaces could facilitate a dynamical process with complex feedback loops; a process that would render the input of the participants and the output of the instrument adaptive and generative.

Finally, the concepts of material integration and distributed cognition were explored in experiments that made the growth of microorganisms, or the affect of the very boundaries of space, visible, audible, and material. As such they aimed to render porous the constraints of observers' distributed cognition through the manipulation of spatial bodies.

In addition to these potentials, limitations were also discovered. The distributed cognition and potential interaction of the participants could not affect the spatial body; it was, in other words, unresponsive. The interfaces were triggered by direct and intentional gestures that made them appear as autonomous buttons rather than integrated materials, and the learning process that the interactive soundscape instrument produced was finite, since the sonic components did not have the capacity to adapt or grow. The discovery of these limitations was perhaps the most important insight yielded from the first research phase because they point towards specific areas of overlap between discovered potentials that are more likely to address these limitations than others and, thus, may be the most productive stepping stones for the next research phase.

LEARNING TO GROW

Working on such points of overlap, Fallah is now developing a material installation body that is based on observations of living slime mould, effectively rendering perceivable growth patterns from our microenvironment. She is adding spatial obstacles to the attractors of the agent-based model in order to set boundaries for growth. The effect provides space for human movement and embodied experience of the installation body. Drawing on Fallah's concepts and ideas, Manuel is interested in softening the boundaries of this body and, as Fallah articulated it, the space it both inhabits and becomes part of. Although the body has a weight-bearing core, Kuzabaviciute and Manuel both imagine its surface as responsive. When one part becomes stretched by weight another becomes more compressed and less elastic. The skin of this body, as conceived by Kuzabaviciute, contains materially integrated interfaces that are triggered by touch and other forms of bodily connection (walking, leaning, etc.). The idea is that complex interfaces with dynamic shapes that are made from materials with inherent behaviour, such as a membrane, may change participants' embodied experience, actions, and relationships. The tactile computing of these interfaces triggers and affects the qualities of several sound layers that are imagined and created by Soydan. These sounds provide background, are programmed to grow, or are introduced and controlled by the participants' interaction alone. Instead of anticipating and playing the participants' embodied autobiographical memories, the sounds target an emotional response directly through the effects that soft, fast, or sharp sounds have on the participants' bodies and orientation in space. The personality Manuel imagines for this organism balances the algorithm of growth that is represented in the body and the principles through which the sound is generated with the concept of aging and decay. Manuel asks: what if the texture of the skin erodes like rusting metal, what if the wear and tear of interaction leaves visible and audible traces, what if random input sources keep the participants' and the organisms' learning curves alive and perhaps even cause unlearning?

Such choices may enable the group – and others drawing on their work – to understand and reach that utopian moment when human–environment interactivity becomes conductive, generative, adaptive, and learns to grow.

INDIVIDUAL PATHS AND COLLECTIVE PROCESSES OF ACTUALIZATION

Pursuing these ideas with an emphasis on individual interests and strengths, Fallah has advanced from imitating slime mould to actually growing it, extracting its embedded principles of behaviour, and using them as a tool to develop an algorithm that can reproduce the slime mould's interaction and growth. This method of transfer enables her to represent the material product of biological processes on a large, human scale and as a living space with radically different constraints and possibilities of movement than familiar built environments.

In more technical terms, the algorithm is coded in Rhinoceros 3D Grasshopper, a computational design program capable of generating three-dimensional models of self-organizing networks. The shape of the human body plays a vital role in the configuration and organisation of the generated form. Thus, for the design of this installation, the expected pathways through the material structure that are necessary for audience movement are embedded into the program as obstacles that deter growth in certain areas.

Fallah is deeply invested in conceiving and building an installation body that, by providing different constraints and pathways for a visiting spectator's choreographic performance, may affect both this spectator's movement and sensorimotor perception performatively. This material body is not responsive, anticipated, or textually integrated. The object depends on layers of skin, emotion, and personality to realize these concepts.

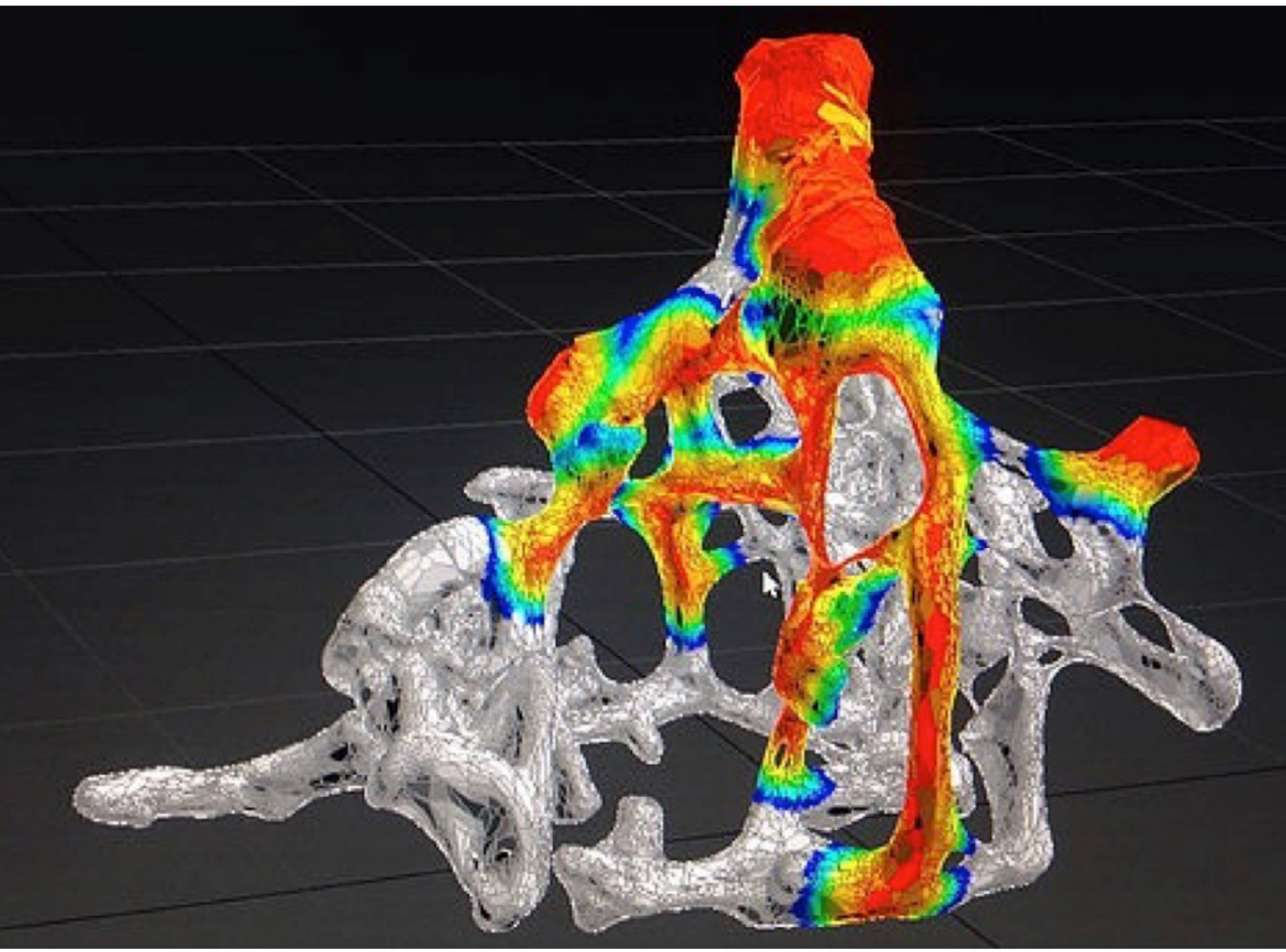

Figure 6-7: Digital renderings of agent-based modeling. Photo: Roxane Fallah, 2017.

Manuel proposes to use a combination of soft cotton wool, string, various textures, and compostable organic materials to blend boundaries and set in motion a continuous process of response and decay. She wishes to study how such porousness, integration of material textures, and softening of cognitive constraints affect the performance in the space of participants with discipline-specific training in proprioception and embodied action. That can be done through situations like the experiment illustrated in Figure 8, where dancers are invited to inhabit the space.

Figure 8: Two dancers, Elizabeth Burney and Hillary James, are interacting with an early installation prototype. Photo: Bianca G. de Manuel, 2017.

Kuzabaviciute is exploring and designing diverse sensors and imagining how they can become materially integrated through the usage of conductive ink or by embedding them in haptically responsive surfaces of different kinds. Her contribution invites participants to explore a maze of responsive textures through touch and by looking for the clues for the next unpredictable action. Kuzabaviciute thinks that various forms of tactile stimulation will solicit a comparable variability in interaction. As participants explore interfaces with their hands, access them by reaching through various textures, or trigger sensors with their feet and on their knees, their interaction invites new embodied relationships with the environment and among participants. Although input and output sources of the interfaces are essential for the functionality of this design, they are not set up in a one-to-one relationship. Differentiated and random effects, which are programmed, and the non-programmed responses of participants described above merge to render the work anticipatory and responsive.

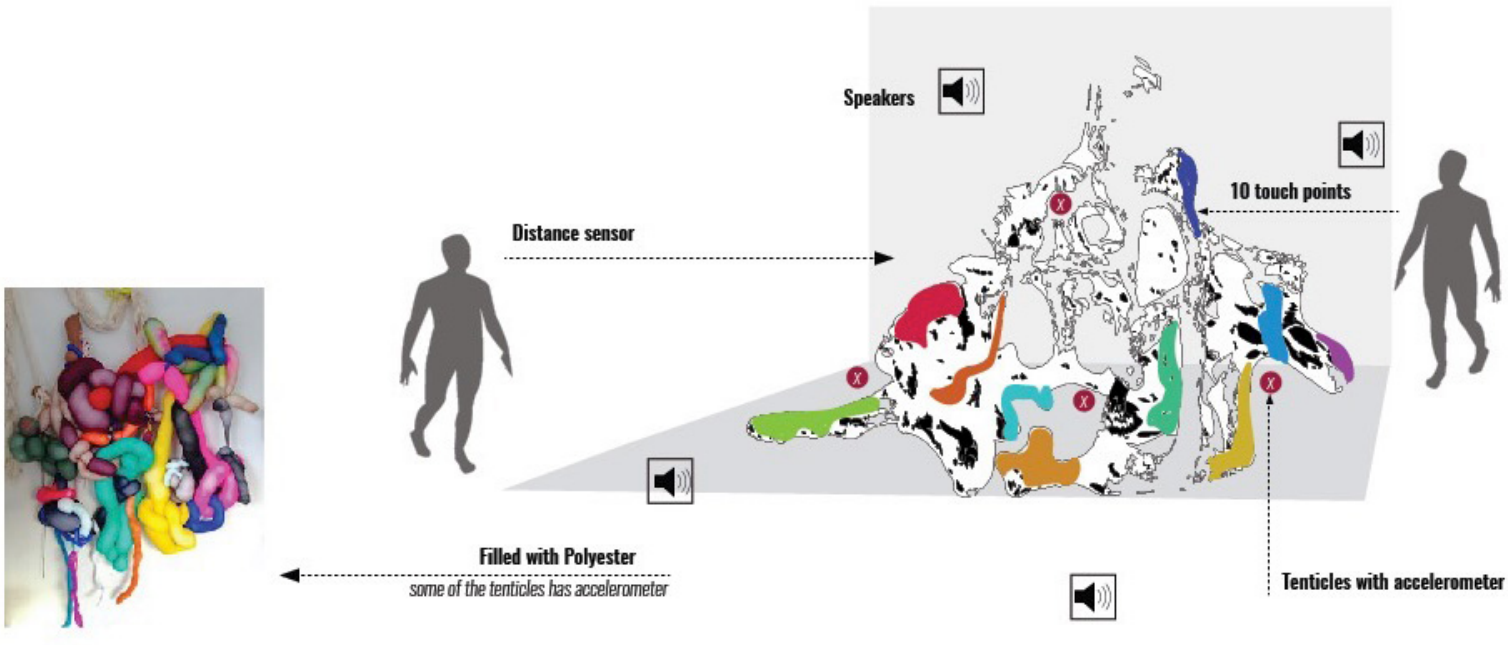

Figure 9: Concept sketch of installation with materially integrated and anticipatory skin. Photo: Gabriele Kuzabaviciute, 2017.

Soydan is changing his approach in response to the collaborators' proposals. Instead of thinking of a speaker as an agent, he approaches the entire space as a whole. Four speakers are used to sonically localize and reflect the agents' behaviour in the room. He works with four layers of sound that are introduced and added up through interaction and over time, causing sound generation and representing growth. Three of these layers offer an immersive atmosphere and the fourth and main layer is interactive. Some of the sensors that are embedded in the skin affect the qualities of the main layer, others affect the atmospheric layers simultaneously. The main layer of the sound is created by a method called *Granular Synthesis*. Sound samples are split into tiny bits (grains) and randomly reordered to create new sounds over time and through principles that are comparable to agent-based modelling. The general timbre is always similar, but the sound itself is unique. Each of the grains' parametres can be controlled, such as the pitch and amplitude, which gives Soydan the freedom to create a greater variety of sounds.

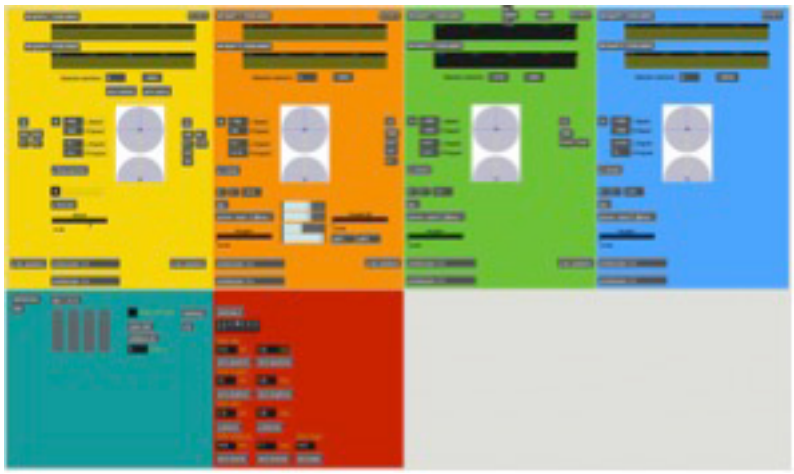

Figure 10: Max/MSP patch. Image: Abdullah S. Soydan, 2017.

Although the intention is to learn to grow, solicit embodied and sensory interaction, and embed generative principles of responsiveness in the design together, the ideas presented here reflect the distinct training and design norms of each collaborator. To integrate these ideas in a way that can bring the group closer to their utopian objective, a mutually contaminating process of communication and collaboration is needed.

As Manuel reflects: to be a designer for the stage in Canada typically means to be able to envision something and realize it. Changes within a process are understood as a lack of clarity of vision. This fundamental expectation of clarity and implementation can work against interdisciplinary collaboration and Practice-as-Research. Manuel argues that how we work affects what we create and that the group's process of creation thus needs to reflect the same theoretical framework that they aim to realize in their creation. In other words, it would be beneficial to design a process that is responsive to emergent events, to accidents, and invited proposals from the collaborators: a process of experimentation with agreed-upon tasks and procedures of creation – as is common in dance (EUGENIO; FIADEIRO, 2013). Such a process could render porous the constraints of each specific discipline as a foundational condition of irreversibly performative interaction.

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