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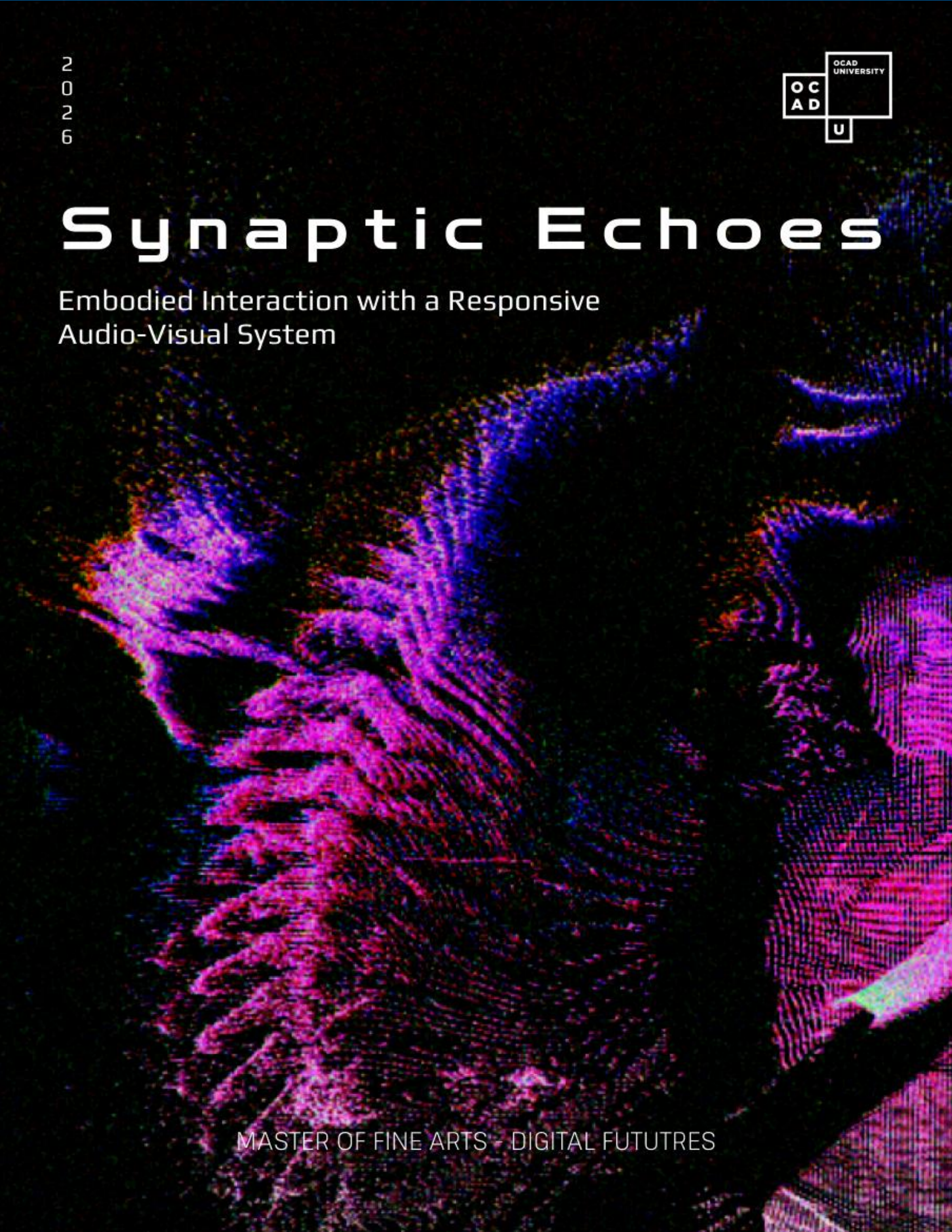

# Synaptic Echoes

## Embodied Interaction with a Responsive Audio-Visual System

MASTER OF FINE ARTS - DIGITAL FUTUTRES

# Synaptic Echoes

by
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# Abstract

*Synaptic Echoes* is an interactive installation that examines how bodily presence and temporal interaction shape co-creative behaviour within a sensor-based technical system. Grounded in affect theory, embodied interaction, and research-creation, the project investigates how gesture, proximity, and touch generate multisensory responses across sound, light, and material form. Rather than treating technology as a reactive tool, the installation operates as a relational ecology: an environment that senses, registers, and adapts through encounters with multiple bodies.

Drawing on Erin Manning's concepts of attunement and the minor gesture, and Gilbert Simondon's account of technical individuation, the project reframes agency as distributed and emergent through encounter. A three-layer memory model- immediate response, temporal echo, and long-term trace- structures the system's behaviour, enabling prior interactions to persist and shape future ones.

Participant movement is captured through depth sensors, pressure interfaces, and gestural tracking systems. These inputs are processed through TouchDesigner, where they are integrated and translated into evolving audiovisual phenomena that unfold over time.

The project follows a research-creation methodology grounded in iterative prototyping, reflective analysis, and material experimentation. Prototypes such as tactile sensor objects and Kinect-based visual systems function as sites of inquiry into attunement, embodied agency, and co-presence. Through iterative cycles of making and reflection, the project moves from object-centered interaction toward spatial, collective mode of co-creation.

Ultimately, *Synaptic Echoes* asks how a technical system might not only respond to participants but also retain traces of their presence, cultivating an environment in which human and technical processes become attuned through shared gestures, accumulated memory, and affect unfolding over time.

## Key terms

co-creation, attunement, co-presence, distributed agency, feedback, memory, sensors, duration, Affect theory, Cybernetics, Interactions, Interactive installations, embodiment.

## Land Acknowledgment

This work was developed in Tkaronto/Toronto, on the traditional territories of the Mississaugas of the Credit First Nation, and the ancestral lands of the Anishinaabeg, Haudenosaunee, and Huron-Wendat Peoples. Toronto is also home to many First Nations, Inuit, and Métis communities today.

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Throughout this thesis, I was often left feeling clueless. The tools, the software, the skills, I needed to learn but did not know how to utilize! But because of the great minds I had access to at OCAD, I now know how temporary this feeling of cluelessness can be.

First, I want to thank Simone Jones, my Primary Advisor, who shaped me into the artist I could be. You opened my mind to installation, expanded the way I think about art and digital forms, and helped me believe that my ideas are only ever some time and effort from taking shape in this world. Your patience, generosity, and belief in my work have meant so much to me, and no matter how many times I retype this, I'm never satisfied with the appreciation I'm conveying to you.

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# Glossary

*I am including this Glossary at the beginning of the document to connect and elucidate the key terms, theories and concepts that have informed this thesis and the physical manifestation of the installation.*

## Attunement

Drawing on Erin Manning's account of preacceleration, I use attunement to describe an incipient bodily orientation that is felt before deliberate action (Manning 2009, 6). What Erin Manning describes through *preacceleration*, when relation is already underway before movement becomes an intentional act. She defines "preacceleration" as "a movement of the not- yet that composes the more- than- one that is my body" (Manning 2009, 13). In *Synaptic Echoes*, attunement is the ongoing calibration between a participant's bodily activity and the installation's sensing field. Movement, proximity, touch, and sound enter the system as continuous signals that modulate audiovisual behaviour over time. Attunement is not something the participant possesses, and it is not the system "interpreting" meaning; it is a relation that takes shape across bodies, sensors, and space.

## Co-Creation

Co-creation is the process through which a human and a technical system shape meaning, form, and behaviour together over time. It is less about producing discrete outputs than producing relations through feedback, adjustment, and accumulation. In *Synaptic Echoes*, co-creation emerges through the circulation between bodies, sensing, and response, where participants learn the system's sensitivities and the system's evolving states condition what becomes possible next. Manning's reminder that "there are always at least two bodies" supports co-creation as something constituted through encounter (Manning 2009, 13).

## System

In this thesis, *system* refers to the technical system of *Synaptic Echoes*: sensors, computational processes, timing and memory logic, and audiovisual outputs that register bodily activity and generate response over time. Myron Krueger describes this shift in interactive environments as a move from "input from a user" toward a system that "perceives the behaviour of a participant in the context of a graphic world" (Krueger 1991, 102).

The system does not include the human participant, and it does not imply cognition or intention. I use *system* as an analytic boundary to describe the apparatus and its operations. Karen Barad describes this kind of boundary as an "agential cut" enacted by an apparatus within a phenomenon (Barad 2007, 175–76).

When activated through bodily activity, the system operates within the installation environment: a relational ecology formed by bodies, sensing, spatial conditions, and traces.

## Memory

Memory here is not cognitive recall, symbolic representation, or data storage. It is a form of temporal persistence through which prior interaction continues to shape what the system can do next and how the installation is felt over time. Brian Massumi frames the past not as a stored record but as an active temporal force; elsewhere he writes that ‘Past and future brush shoulders with no mediating present between’ (Massumi 2002, 31).

The installation’s system memory registers presence and gesture through accumulation, delay, and decay. This memory does not store discrete events. It retains changing patterns of intensity, frequency, and spatial concentration, and these patterns modulate audiovisual response over time. Manning also describes memory as event-based, writing that ‘This becoming-event creates a memory that feeds into future movement’ (Manning 2009, 25). This aligns with how memory functions in *Synaptic Echoes*: not as a record, but as a carryover in the system’s state.

Atmospheric memory appears at the scale of the installation environment as persistence in light, sound, and material change that conditions later interaction. In this sense, memory is not a record of the past. As Barad writes, “Memory is not a record of a fixed past that can ever be fully or simply erased, written over, or recovered and remembering is not a replay of a string of moments, but an enlivening and reconfiguring of past and future that is larger than any individual.” (Barad 2007, ix).

### Decay

In this thesis, decay names the gradual loosening of traces over time within the installation. It does not mean failure or disappearance, but the temporal process by which prior interactions lose intensity while still shaping what can happen next. In *Synaptic Echoes,* decay keeps memory active without preserving it intact, allowing new encounters to enter, overlap, and alter what remains.

## Presence

Presence is a contested term across media studies and performance theory. In *telepresence and virtual reality research*, presence is often defined as the sensed “being in” an environment, whether that environment is direct or technologically mediated (Steuer, 1992, 75). In performance theory, presence is often understood as something that emerges in the event itself through the embodied relation between performers, spectators, and the conditions of performance (Fischer-Lichte 2008, 4, 8). *Synaptic Echoes* draws from these framings but locates presence in embodied participation that becomes legible to a responsive system.

In *Synaptic Echoes*, presence is understood not as subjective awareness or psychological attention, but as bodily participation within a responsive environment. Presence emerges when a human body enters the installation space and becomes perceptible to the technical system through movement, proximity, touch, sound, or other forms of physical activity. Presence is therefore relational rather than internal. It is not something the participant possesses, but something that arises through interaction between bodies, sensors, and spatial conditions.

This relational framing aligns with Erin Manning's account of movement as space-making rather than movement inside a fixed container which matches with Manning's claim that movement does not enter space only, it also creates it (Manning 2009, 15). For *Synaptic Echoes*, this matters because the installation does not treat the room as a neutral vessel that a participant occupies. The room is continuously reconfigured as a felt and sensed field through gesture, proximity, and contact. Manning's claim that "there are always at least two bodies" also clarifies that presence is not a solitary state, even when only one participant is foregrounded, because relation is constitutive of the event (Manning, 2009, 13).

From the system's side, presence is not recognized as meaning. It is registered as changes in state. Lucy Suchman emphasizes the asymmetry of human–machine interaction and asks how events register from the machine's 'point of view' (Suchman 2007, 5). In *Synaptic Echoes*, sensors do not interpret presence cognitively. They register continuous variations in activity as signals that modulate audiovisual behaviour. Presence is therefore not reducible to a single moment of detection. It unfolds through rhythm, intensity, and duration.

Presence in *Synaptic Echoes* is durational, and trace based. As bodies move, pause, withdraw, or return, the system holds residual effects of prior interaction as changing parameters, states, and accumulated modulation. Fischer-Lichte frames performance as a spatial, embodied event rather than a fixed work, which helps situate performative space as something that emerges through movement and staging conditions rather than existing in advance (Fischer-Lichte 2008, 4, 6).

### Agency

In this thesis, agency names the capacity to have an influence in what unfolds within the installation. It is not treated as intention or ownership, but as an effect distributed across participants, sensors, timing rules, memory processes, and material conditions. Agency becomes visible through the changes these elements produce in what can happen next.

### Interaction / Intra-action

In this thesis, interaction names the observable sensing–response loop in the installation: how movement, proximity, touch, and sound are registered and translated into audiovisual change. Intra-action, following Barad, names a different claim: that the participant, system, and environment do not fully pre-exist the encounter as separate entities, but take shape through the relation itself. Interaction therefore describes how the installation operates, while intra-action describes how that relation is understood.

## Duration

In *Synaptic Echoes*, duration names interaction as lived continuity rather than clock time. Henri Bergson describes this as 'pure duration, of which the flow is continuous' (Bergson 1911, 243). In the installation, duration is designed through delay, accumulation, and decay, so interaction is shaped by what has already happened and by what is still unfolding. Krueger notes that participants adapt to what the system can perceive over time; behaviour that evokes no response is less likely to recur (Krueger 1991, 102). This makes the work legible as a feedback relation: the system responds to the interactor, who in turn responds to that response (Rokeby 1995, 137). Duration is also spatial. Erin Manning writes, "Space is duration with a difference" (Manning, 2009, 13), and frames movement as producing the space it comes to inhabit (Manning, 2009, 15). In this project, duration is the condition that allows presence to persist as trace and lets co-creation form across repeated contact.

## Meaning

In *Synaptic Echoes*, meaning is not treated as symbolic representation or linguistic interpretation. Meaning is affective and relational sense-making that emerges through bodily engagement, temporal persistence, and reciprocal interaction with a responsive technical system.

Affect theory helps frame this as prior to, and alongside, conscious interpretation. Brian Massumi argues that intensity can register before it is qualified in language, since "the skin is faster than the word" (Massumi 2002, 25). Meaning here sits in shifts of sensation, rhythm, and attention as bodies attune to an evolving field (Massumi 2002, 25-26).

Meaning does not reside in discrete outputs alone. It arises in the feedback relation itself. Rokeby describes interactive work as a dialogue in which 'The Interactive system responds to the interactor, who in turn responds to that response. A feedback system is created' (Rokeby 1995, 137). He also writes that in interactive video works, 'the content is contained in this difference between the gesture and its transformed or recontextualized reflection' (Rokeby 1995, 145). In this installation, meaning emerges through echo, delay, and accumulated traces rather than messages. This is consistent with Barad's claim that 'Matter and meaning are not separate elements' (Barad 2007, 3).

Within this framework, meaning is not authored by the human alone and not generated by the system alone. It emerges through co-creation as an embodied process that unfolds across interaction over time.

## Cybernetics

Norbert Wiener describes cybernetics as a field concerned with control and communication in machines and living organisms, organized around the logic of feedback (Wiener 1948, 14). In *Synaptic Echoes*, cybernetics names the feedback relations through which sensing, response, and audiovisual modulation shape later movement and interaction.

# Chapter I.
# Introduction

I vividly recall the emotions that lingered after watching Wall-E (2008), The Iron Giant (1999), or even IKEA's "Lamp" commercial (2002), where a discarded lamp "looks" back through the window as it is replaced. I was a child, yet I felt the weight of their loneliness as if these objects could feel. At the time, I wished for one magical ability: to speak the language of animals, to understand beings whose communication I could not decipher. What I did not know then was that communication does not require words, nor does connection require a shared biology. Sometimes it is enough to tune into a rhythm, a gesture, or an intensity to crack the code of connection.

As I grew older, this sensitivity quietly migrated into my relationship with objects. My iPad, my PlayStation, and my first camera were never neutral tools. They traveled with me, witnessed me, and held the movements of my hands. When my camera was stolen during my first internship, the loss felt strangely personal. I didn't replace it and stopped taking photos for a long time. It felt like I had lost something that had become part of me.

Only much later did I understand that this feeling was not about animism or imagination, but about attunement: a relational sensing that emerges through gesture, rhythm, and response before meaning is fully articulated. That understanding informed both the project and its title. *Synaptic* points to transmission, threshold, and relay: the way signals pass across bodies, sensors, and computational processes rather than belonging to a sole source. *Echoes* points to what returns after the moment of action: delayed sound, visual persistence, and the lingering traces through which the installation remembers. Together, the title names a system in which relations are carried across time. Presence does not end in the instant of contact; it passes through the installation and returns altered.

In *Synaptic Echoes*, this relational sensing is shaped through the system's conditions: sensing technologies register bodily presence and modulate audiovisual responses, drawing participants into a shared responsive environment. What emerges is not a fixed exchange between user and system, but a shared condition shaped through encounter over time.

*Synaptic Echoes* begins from that intuition:

That connection with the nonhuman is not absurd, nor naïve, nor childish.

but a genuine mode of relating that deserves to be designed for.

What if we created systems that respond not as tools, but as relational partners?

What if presence, movement, breath, and pressure could become a shared language?

What if a machine could remember us, not as perfect data, but as traces, impressions, echoes?

After posing the question of what it means to form a relationship with a system, it becomes necessary to describe the system itself, what it is, how it behaves, and why it exists. This is where *Synaptic Echoes* takes shape: not as a metaphor, but as a material, spatial, and sensorial environment that invites visitors into a form of co-creation.

## What the Project Is

*Synaptic Echoes* is a multisensory research-creation project that explores the possibilities for co-creation between a human and a sensor-based technical system. It is not a single object, nor a fixed interface, but an installation environment composed of spatially arranged sensors, materials, light, sound, and temporal processes that together form what I describe as a technical body.

In this thesis, the environment refers to the spatial and material conditions of the installation: the room, physical elements, and atmospheric qualities that participants engage. The technical system refers more narrowly to the network of sensing technologies, computational processes, and audiovisual outputs that register presence and modulate behaviour over time (Figures 1 and 2). The term technical body describes the system's capacity to behave cohesively, not as a living organism, but as an integrated assemblage whose responses emerge through relational interaction rather than simple reactions.

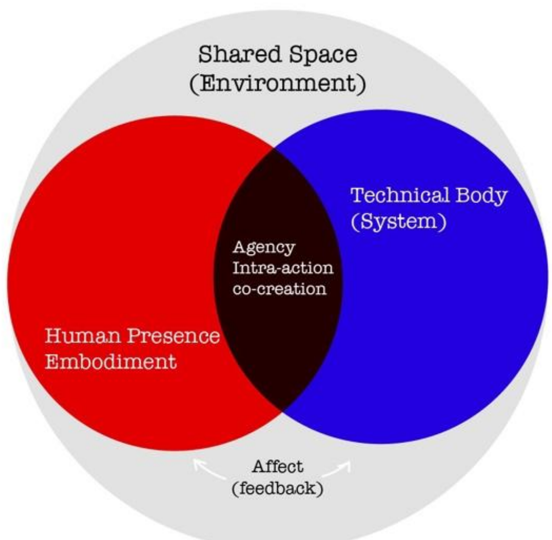


*Figure 1. Conceptual structure of Synaptic Echoes as a shared relational space, situating human presence and the technical body within an environment where affect, agency, and co-creation emerge through intra-action.*

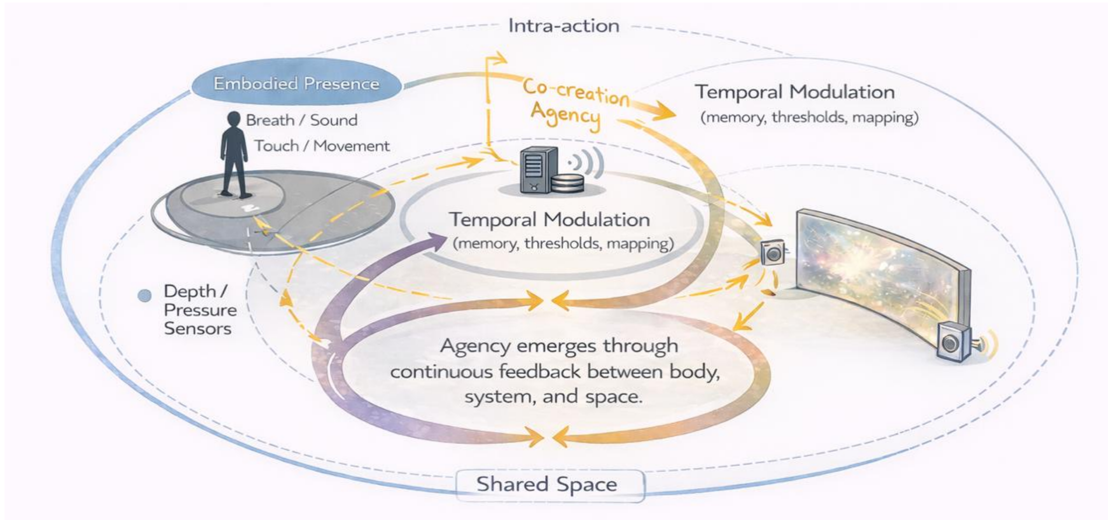


*Figure 2. Relational dynamics between human presence and the technical body in Synaptic Echoes*

Where your movement alters the light. Your proximity stirs the sound. Your touch deforms an object that remains bent long after you walk away.

This environment does not respond to a generic user, but to bodily presence understood as rhythm, tempo, and variation over time. *Synaptic Echoes* is built around the idea that presence is generative; that interaction is not a moment, but a duration; and that memory is not storage, but trace, echo, and persistence.

When this project refers to memory processes, it does not mean the artist's memory or the participant's recollection, but the system's operational memory: temporal mechanisms through which prior interactions continue to influence behaviour. Through these mechanisms, the system retains patterns rather than discrete events, so past presence gradually shapes future encounters.

The project asks what becomes possible when a system is designed not as a tool, as part of a relational field, not because it possesses cognition or intention, but because it can sense, respond, and register change over time. This kind of relation requires time: time for responses to emerge, for traces to accumulate, and for past interactions to shape what comes next.

## Contribution

This thesis contributes a research-creation account of designing *Synaptic Echoes* as a multisensory system where interaction is treated as a relation that unfolds over time. Through iterative prototyping, I develop a three-layer memory model (immediate response, temporal echo, long-term trace) and use it as both a design strategy and an analytic lens for thinking about co-creation, attunement, and distributed agency in sensor-based installation practice. The chapters move from project framing and context to theory and methods, to prototype analysis, installation design, and conclusions.

## Research Questions

As humans, we are shaped by our environments—by the bodies, objects, and rhythms around us. As machines increasingly inhabit these environments, the question becomes not only how we use them, but how we coexist with them. *Synaptic Echoes* investigates whether a human and a technical system can form a relationship grounded in attunement, memory, and mutual influence, rather than utility or instrumental control.

When a visitor enters the installation, they do not simply trigger responses; they alter the system in ways that can persist across time. Likewise, the system shapes the visitor's movement, attention, and orientation through evolving audiovisual and spatial behaviour. This reciprocal shaping, unfolding through bodily presence and duration, forms the core of the research inquiry.

### Primary Research Question

How can humans and a sensor-based technical system co-create evolving audiovisual and spatial states through bodily presence, duration, and accumulated system memory within a shared installation environment?

This question investigates the central possibility of the project: that a human and a technical system can shape an evolving installation together over time without fully determining its outcome. *Synaptic Echoes* retains traces of prior interaction, so earlier encounters can affect what happens next.

The research explores how bodily presence—expressed through movement, proximity, touch, and sound—contributes to the system's evolving behaviour, and how the system's shifting audiovisual states, in turn, guide the participant's actions and attention.

Co-creation is treated not as the production of discrete content, but as the production of relation: an emergent process that unfolds through continuous feedback between human bodies, system processes, and spatial conditions.

### Secondary Research Questions

1. How do attunement and agency support co-creative exchange between participants and a responsive technical system?

In *Synaptic Echoes*, co-creative exchange emerges through bodily and technical sensitivity to micro-gestures, shifts in proximity, and variations in presence within the space. Agency, in this context, is not an individual possession but a shared capacity that emerges through interaction. When both humans and systems can influence one another over time, agency becomes distributed and relational. This question examines how co-creative exchange emerges when attunement and agency intertwine, as participants adjust their movements in response to the system's behaviour, and the system, in turn, modulates its responses based on accumulated interaction.

2. How do memory, duration, persistence, and trace shape interaction, system behaviour, and agency?

Memory in *Synaptic Echoes* is not conceived as a static archive but as a temporal force that operates through persistence, delay, and decay. It is enacted through layered responses: immediate reactions, delayed echoes, and slower traces that linger after participants leave the space. This question investigates how these temporal layers shape both the evolving behaviour of the system and the participant's experience of interaction. When the system retains traces—a bent material form, a fading visual field, or an echo of sound—subsequent visitors encounter not a blank environment, but the residue of prior presence. In this way, memory becomes a co-creative material, altering what is possible in the next moment and contributing to a dynamic temporal ecology shaped collectively across encounters.

These research questions aim to shift the understanding of human–machine interaction from a transactional model ('input → output') to a relational model grounded in sensation, duration, and mutual influence. The project seeks to create an environment where presence becomes a form of communication, and where traces of that presence participate in shaping future encounters.

# Chapter II.
# Background

## Why Human-Machine Interaction?

Before *Synaptic Echoes*, when I was beginning to think about co-creation and machine attunement, I made a project called *Echoes of the Unseen*. It began as a question that sat in the background of my practice:

How do objects hold memory, and what does it mean to encounter a past that still feels present?

*Echoes of the Unseen* clarified something important for me. I was not interested in interaction for the sake of interactivity. I was interested in relationship, in the small affective bridges that form when we encounter inanimate or technological artifacts that feel attentive, haunted, or charged, as if they carry more than their material form alone suggests.

## Echoes of the Unseen

*Echoes of the Unseen* was an audiovisual interactive installation centered around an old radio and a surrounding video projection. When participants turned its knobs, the radio no longer functioned as a broadcasting device, but as an interface through which fragments of sound and image were revealed over time. It offered access to recorded traces of a household that no longer existed, inviting participants to scroll through moments, to listen, to linger.

Through layers of sound, static, and flickering visuals, participants encountered fragments of past events, weddings, dinners, playdates, moments of war, and silence. These moments did not unfold as a complete narrative, but as partial impressions: interrupted, uneven, and shaped by distortion and absence. The effect of the work emerged not from the radio alone, but from the relationship between the object, the surrounding space, the projected images, and the participant’s bodily engagement (Figure 3).

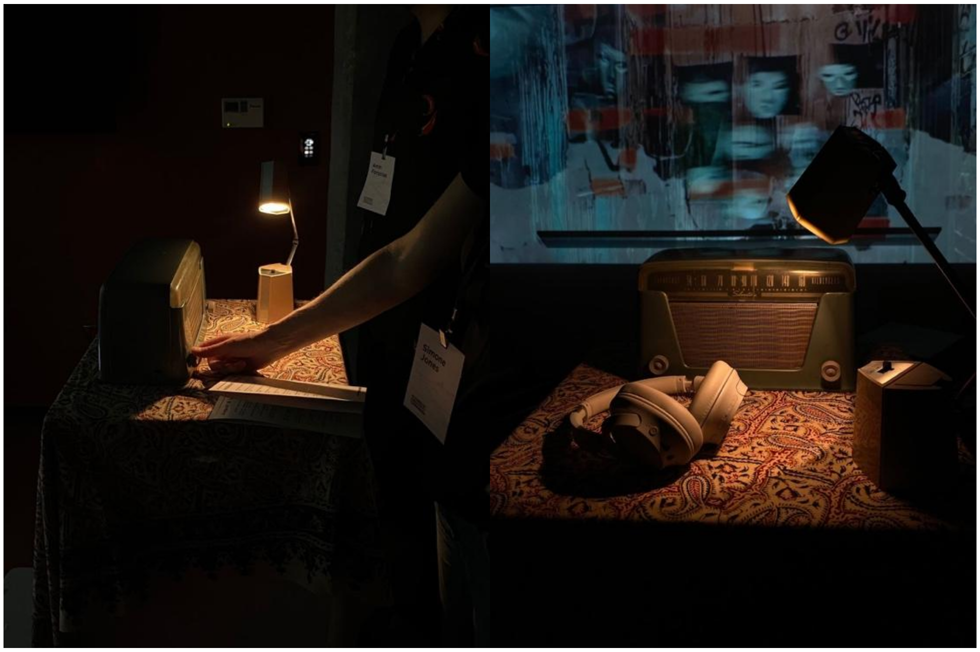

*Figure 3. Echoes of the Unseen (interactive installation). Turning the knob allowed participants to scroll through fragments of sound and projected visuals in the space.*

For a moment, the object stopped being “just” a radio.
It became a point of orientation, a material anchor around which memories gathered.
Not because the radio remembered, but because it staged an encounter with what remained. This piece taught me that everyday objects can carry emotional residue. They survive us, outlive us, and bear the marks of repeated use: the wear of hands that once turned their knobs. But it also revealed a crucial limitation.

The radio could tell a story, but it could not listen. It could not change. It could not grow with the person interacting with it.

Participants could move through the material, modulating what was revealed, but the system itself remained unchanged by their presence. It held memory as an archive, not as a process. The exchange was one-directional: poignant, intimate, but closed.

This realization later shaped my interest in systems that do not simply present traces of the past, but can register presence, retain change, and evolve through interaction over time.

## From Witnessing to Exchange

When I finished that project, I found myself returning to a single question: What would it mean for the object to respond— not by replaying a memory, but by generating something new that emerges through the encounter itself? The radio was fixed in its past. It could reveal memories, but it could not develop new ones. It could not be changed by the presence of the participant. It remained a one-way interaction device, not a collaborator.

This became the catalyst for my shift toward relational systems. I began imagining an interaction that could unfold across time, where the system and the visitor form something together rather than the visitor stepping into a predetermined narrative. This desire for a more reciprocal, evolving, co-creative encounter is where *Synaptic Echoes* first took shape.

## Early Interaction Experiments

The transformation from *Echoes of the Unseen* to *Synaptic Echoes* developed through a series of early prototypes. These experiments taught me more about relational design than theory alone could. I noticed that when the object was visually striking or unfamiliar, participants became preoccupied with its form. Their attention shifted toward interpretation rather than engagement. If the object felt overly sculptural, it became spectacle rather than partner. And when it appeared too delicate or "precious," people interacted cautiously instead of playfully, limiting the potential for an evolving relationship.

These encounters pushed me toward an object that was materially quiet: familiar enough to approach without hesitation, and intuitive to touch. I began prioritizing the conditions that support the emergence of relationship, rather than treating the object as the endpoint of attention.

## From Echoes to Synapses

What binds these two projects together is an enduring interest in memory, not as an archive of stable facts, but as an affective residue that persists, shifts, and continues to act in the present. In *Echoes of the Unseen*, memory was encountered through the radio as pre-existing material: recorded traces of a past that participants could access but not alter. While these memories could be interpreted and felt differently by each person, the system itself remained unchanged by their presence.

Brian Massumi argues that incipience 'cannot just be a conservation and reactivation of a past' (Massumi 2002, 30). What distinguishes *Echoes of the Unseen* from *Synaptic Echoes*, then, is not the existence of memory itself, but how memory is operationalized within the system.

In *Synaptic Echoes*, memory is produced in the present through interaction between human bodies and a responsive technical system. Rather than encountering memory as content given in advance, participants contribute to it as an ongoing process shaped by gesture, duration, and repetition.

The shift is subtle yet transformative. Memory becomes shared rather than individually received, reciprocal rather than one-directional, and emergent rather than predefined It is no longer something one investigates, but something that takes form through participation and persists as a trace into what happens next.

This chapter marks a bridge between two ways of thinking about interaction. *Echoes of the Unseen* invited participants to encounter traces of an object's past. *Synaptic Echoes* builds a system that can register, retain, and respond to the presence of those who engage with it over time.

## Scope and Limitations

The field of human-machine co-creation is expansive. It spans artificial intelligence, advanced robotics, virtual and augmented reality, immersive simulation, social computing, affective interfaces, multi-agent systems, and speculative forms of artificial life. Each of these domains offers its own possibilities for collaboration, perception, and shared agency. This project could be imagined as unfolding through fully immersive virtual environments or through machine-learning systems capable of generating complex behavioural adaptations. However, these possibilities extend far beyond the scope of a one-year master's thesis and lie outside the intentions of this work.

This thesis focuses specifically on the relational, behavioural, and affective dimensions of human-machine interaction within a shared physical environment. The installation does not attempt to simulate intelligence, create virtual worlds, or develop predictive or learning algorithms. Instead, it concentrates on subtler forms of co-creation that emerge through presence: movement, proximity, touch, breath, sound, and the lingering traces these actions leave behind.

A wide constellation of themes intersects with this project: memory, embodiment, spatial atmosphere, cybernetic feedback, affect theory, and material responsiveness. Yet not all these themes can be explored with equal depth. For this thesis, I prioritize the following areas: how the system senses bodies, how it responds over time, how traces of interaction accumulate and influence future behaviour, and how participants, system processes, and material conditions together shape what can happen next.

Rather than developing a highly intricate or sculpturally complex object, I limit the material form to something familiar and approachable, while recognizing that its appearance still shapes whether people notice it and choose to interact. This decision allows the research to focus on the quality of interaction rather than the aesthetic spectacle of the object.

Similarly, this thesis does not include extensive user studies, formal psychological analysis, or empirical measurement of human behaviour. While such methods could offer valuable insights, they belong to a different methodological framework. My approach aligns with research-creation, where knowledge is generated through making, reflection, and embodied engagement with the system as it evolves.

By defining these boundaries, I aim to clarify that this thesis investigates a specific question: how co-creation can arise between humans and a responsive system through memory, attunement, and presence. It does not seek to address the full scope of artificial intelligence, immersive simulation, or large-scale interaction design. Instead, it focuses on the small exchanges that unfold within a single installation, and on how meaning forms in the space between human and machine.

# Chapter III.
# Literature Review

## Overview

*Synaptic Echoes* stems from a desire to understand how human participants and a sensor-based technical system can meet through time and interaction.

The installation creates a setting where bodies, materials, and sensor signals shape one another. Touch and movement persist as traces through the system's memory processes immediate response, delayed echo, and a longer-term trace that accumulates and fades.

To locate this work within a broader field, the literature review turns to thinkers and artists concerned with relation, sensation, and embodied response. Erin Manning offers a way to think about the incipient phase of movement as something felt before deliberate action fully takes form (Manning 2009, 6) In *Synaptic Echoes*, this connects to how minor changes in proximity, gesture, and touch are sensed and translated into audiovisual change.

For Gilbert Simondon, the technical object is not a finished thing, but something understood through its genesis. He writes that it is present 'at each stage of its coming-into-being' and that 'in its oneness' it is a 'unit of coming-into-being' (Simondon 2017, 26). This thesis treats duration and memory as forces that shape the present, such that prior interaction continues to affect what happens next (Massumi 2002, 31; Bergson 1911, 238).

This chapter traces a selective lineage of interactive art that uses sensors and feedback to shape experience over time. I focus on works that treat interaction as relational and temporal. Examples include feedback-based installations and responsive environments that use sensing to shape sound, image, and atmosphere (Krueger 1991; Rokeby 1995; Lozano-Hemmer 2006). This lineage is included to frame the problem space and to clarify what this project is trying to do differently.

Together, these perspectives on affect and attunement, technical individuation, duration and memory, and intra-action provide the conceptual ground for *Synaptic Echoes.* In this thesis, Interaction becomes memory when responses persist, fade, or accumulate across time. Memory becomes a condition for co-creation because past traces of presence shape what can happen next.

## Affect and Attunement

Affect describes what happens in experience before naming it. Seigworth and Gregg write that 'Affect arises in the midst of in-between-ness' and is found in 'those intensities that pass body to body' (Seigworth and Gregg 2010, 1). Massumi distinguishes affect from emotion by describing emotion as intensity once it has been qualified and folded into function and meaning (Massumi 2002, 27). I use affect here to name intensity that has not yet settled into a recognized feeling or a stable interpretation.

Erin Manning extends this into a practice of relation through attunement. Manning extends this into a relational account in which bodily and technical processes are not neatly separated. (Manning 2009, 24). This matters for *Synaptic Echoes* because attunement is not limited to living organisms. It can include sensor systems and material setups that register and relay forces.

In *Synaptic Echoes*, the participant does not press a button to receive a single output. The system registers proximity, gesture, and touch through sensors. Those signals are translated into shifts in sound and visuals. The participant notices these shifts, adjusts, and tries again. That loop is where a co-creative exchange begins.

Affect moves through this loop as timing and atmosphere. A small delay, a sudden change in resonance, or a trace left by someone else can change how a participant moves and what they choose to do next. This is also where "meaning" sits in this project. It is not a linguistic meaning, it is a felt sense of relation for participants, emerging through timing, atmosphere, and response.

## Co-Creation and Coexistence

Co-creation begins when human and nonhuman bodies enter a relation. In *Synaptic Echoes*, this means the encounter is not only a person acting on an object. The participant and the technical system shape what the interaction becomes over time. Simondon supports this framing by noting that 'the individuality of technical objects is modified throughout the course of this genesis' (Simondon 2017, 21).

This openness matters at the level of the encounter itself. In *Synaptic Echoes*, this can look like hesitation, a half-step forward, a hand hovering before touch, or a change in tempo. These moments belong to what Manning describes as the elasticity of the, when the next movement has not yet arrived but can already be felt as potential (Manning 2009, 32). They matter because the system registers them, and once the system responds. Co-creation begins here because the encounter is already taking shape before either side settles into a fixed action. Suchman extends this emphasis on emergence by arguing that plans can orient action, but do not exhaustively specify its course (Suchman 2007, 71–72).

During the Digital Futures Graduate Fall Colloquium (2025), audience members emphasized that the work was not one user interacting with one object. It registers co-presence, that is, multiple bodies in the space at once, with overlapping gestures and shared attention. I include documented examples from REB user testing below, supported by my observations of participant behaviour.

Co-creation here is collective and time based. Each person contributes to how the installation behaves, and no single author can be isolated. Coexistence, in this sense, is enacted through shared presence, repeated gestures, and traces that shape what can happen next.

Paul Dourish's notion of embodied interaction further supports this orientation. He argues that the world becomes meaningful through the ways we act within it, and defines embodied interaction as 'the creation, manipulation, and sharing of meaning through engaged interaction with artifacts' (Dourish 2001, 126). The installation enacts this materially: as participants move, pause, reach, or lean closer, the system's sonic and visual fields shift in ways that alter how the space is felt and understood. Manning also frames sense-making as enacted through movement: the room becomes recognizable through what bodies do rather than existing as a neutral container in advance (Manning 2009, 15). In *Synaptic Echoes*, participants come to understand the space through what bodies do, while the system registers movement, proximity, and touch as changing input.

## Agency

Agency in *Synaptic Echoes* names the capacity to be effective in what unfolds inside the installation environment. It is not something the participant owns, and it is not something the system "has" as intention. Agency shows up in the effects produced through interaction.

Bruno Latour helps frame this without centering agency in humans. He writes that 'anything that does modify a state of affairs by making a difference is an actor' (Latour 2005, 71). In *Synaptic Echoes*, agency is distributed across participants, sensors, thresholds, timing rules, memory logic, speakers, projectors, and the responsive material interface. Each can shift what becomes possible in the next moment. Agency is therefore distributed across multiple mediators rather than located in a single subject (Latour 2005, 57, 71).

The "installation environment" sits at the center, with "actants" around it. Participants, sensors, TouchDesigner, sound, projection and light, room conditions, memory traces, and the material object can each "make a difference" to what happens. In Latour's terms, they function as mediators because they can modify what they carry forward into the next moment (Latour 2005, 57, 71).

Andrew Pickering helps describe how this agency unfolds over time through feedback. He argues that "the dance of agency…takes the form of a dialectic of resistance and accommodation" (Pickering 1995, 22). In *Synaptic Echoes*, resistance shows up as the system's constraints and tendencies, such as sensor range, latency, smoothing, thresholds, cooldowns, and decay. Accommodation shows up as adjustments on both sides: the participant changes tempo, distance, pressure, or duration, and the system shifts its outputs based on what it registers and what has accumulated in its memory layers.

A participant gesture changes the sensed data. The system processes it through timing and memory logic, and the installation outputs shift sound, light, and form. The participant then responds to those shifts by adjusting their next gesture. Agency appears here as ongoing mutual constraint and adjustment, not as a one-way command.

This loop also produces the installation environment as something enacted, not pre-given. Following Manning, the room becomes knowable through movement rather than existing as a neutral container in advance (Manning 2009, 15). In *Synaptic Echoes*, the "room" is shaped through repeated cycles of gesture, sensing, response, and trace.

Finally, Simondon helps keep the discussion precise about the technical side without anthropomorphizing it. He notes that “the individuality of technical objects is modified throughout the course of this genesis” (Simondon 2017, 21). I take this as support for describing the system as something that takes shape through ongoing adjustment and relational use, rather than a fixed tool that simply executes outputs. Agency, in this installation, is the shared capacity to shape what comes next through feedback within and across encounters.

## Memory, Duration, and Spatial Atmosphere

Memory in *Synaptic Echoes* is not treated as storage, retrieval, or recall. It is treated as temporal persistence: prior interactions that continue to shape what the system can do and how the space is felt. Bergson’s account of duration supports this shift. The present is not a clean instant, because experience is already thick with what has just passed. As Bergson writes, “every concrete perception, however short we suppose it, is already a synthesis, made by memory” (Bergson 1911, 238).

The installation uses a three-layer memory model (Figure 4) to keep interaction durational rather than instant. Layer 1 is immediate response, where proximity, touch, movement, or sound produce real-time audiovisual modulation. Layer 2 is temporal echo, where short delays and returns replay aspects of recent gestures as aftereffects that shift the present state. Layer 3 is atmospheric residue, where interaction accumulates as slow-changing patterns that fade over time and condition later encounters. Together, these layers let presence persist as a trace: interaction does not remain as stored events, but as ongoing modulation of what the system can do next.

This matters for how interaction is framed. If perception and action are already temporally layered, then an installation does not need to “store” the past to be shaped by it. The past can persist as force, delay, and trace. Massumi makes this temporal structure explicit when he writes, “Past and future brush shoulders with no mediating present between” (Massumi 2002, 31). In *Synaptic Echoes*, this appears as echoes, return signals, and slow drift. A gesture is not only an input that produces an output. It is also a modulation that can return later, soften, or intensify depending on what has accumulated.

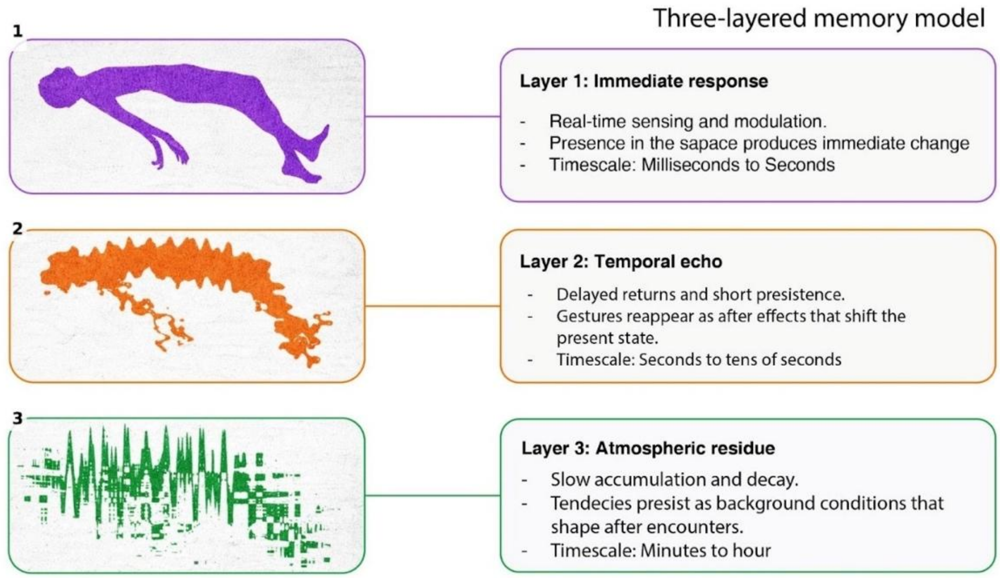


*Figure 4* ***Three-layer memory model for Synaptic Echoes.*** *Diagram by author; diagram supplied by author.*

Karen Barad pushes memory further away from individual cognition by locating it in material relations. "Memory does not reside in the folds of individual brains; rather, memory is the enfolding of space-time-matter written into the universe" (Barad 2007, ix). Remembering, for Barad, is not replay but reconfiguration: "an enlivening and reconfiguring of past and future" (Barad 2007, ix). This supports the project's claim that bodies, materials, and signals fold into one another, such that touch and movement accumulate as traces the system continues to carry forward.

Stiegler ties temporality to exteriorized technical support, arguing that human memory and anticipation depend on tools and artificial memory rather than existing apart from them (Stiegler 1998, 153). He also distinguishes "techno-logical memory" as a third form of memory, beyond genetic and individual memory, grounded in "the exteriorization of the human in language and technics" (Stiegler 1998, 177). In *Synaptic Echoes*, this frames system memory not as private recollection but as a technical support in which traces are exteriorized through accumulation, delay, and gradual fading. The system does not "remember events" as units. It retains changing patterns of intensity, frequency, and spatial concentration through temporal operations that re-enter the present as constraints and affordances. If Stiegler helps frame memory as technically exteriorized, Chun helps clarify that technical persistence is not passive storage but an active process of upkeep.

Here, persistence does not mean storage. It means the continued efficacy of traces: prior interaction still shaping what the system can do next. Wendy Hui Kyong Chun sharpens this point for digital systems by stressing that what appears to persist is produced through ongoing upkeep rather than stable storage. She asks, "Given the ephemerality of digital information, how has electronic memory become conflated with storage?" (Chun 2016, x). This matters because what looks like memory in computation is often produced through ongoing upkeep and repetition. Chun argues that digital persistence depends on continual migration and regeneration rather than simple storage (Chun 2016, 78). In *Synaptic Echoes*, "holding traces" is therefore an active temporal practice: traces persist because the system continually recalculates and remaps them through thresholds, feedback processes, and gradual fading.

If memory and duration are distributed, then spatial atmosphere becomes a key medium through which they are sensed. Gernot Böhme defines atmospheres as "the spheres of felt bodily presence" (Böhme 2017, 118). He also insists that atmosphere requires bodily exposure: "An atmosphere must be palpable, which presupposes bodily presence" (Böhme 2017, 118). Bodily presence is durational in a practical sense, because moving through space takes "time and effort," and it is tied to experiencing "one's own corporeality" through resistance (Böhme 2017, 95). In *Synaptic Echoes*, this appears as carryover in the room itself: sound and light do not reset instantly, traces soften over time, and intensity returns gradually rather than snapping back. During the Graduate Colloquium, informal feedback described the space as carrying a trace of previous visitors' presence, not as narrative content, but as a shift in tone and responsiveness. This is the level at which the work locates memory: as an atmospheric modulation of what can occur next.

The phrase *atmospheric potential* is used here as a project-specific term rather than a quotation. It names the way traces persist as conditions of feeling and action in the room, shaped by duration and by the system's ongoing temporal operations. Memory, in this sense, is not an archive. It is a distributed persistence that links bodies, sensing, and space through accumulation, delay, and decay.

## Fluid memory: duration, decay, and trace

If the memory in *Synaptic Echoes* is framed as something other than "storage," then the next step is to treat time itself as a material condition of the work—something the installation composes with, not something it merely occupies. This shift matters because decay, lingering, and trace are not secondary effects layered on top of interaction; they are part of how the system engages participants across time.

In living systems, nothing holds its form forever: bodies grow and perish, forests store climates in rings, and even stars are born and die. I take this not as metaphor but as an ethical and aesthetic orientation: the installation holds the visitor's trace only temporarily, so that presence is experienced as both real and passing. Decay is what makes this temporariness operative: traces remain long enough to be encountered, then soften so that new encounters can enter.

Bergson offers a starting point for understanding why an installation can feel alive without being anthropomorphized. In *Matter and Memory*, he refuses the split between a world that is purely "out there" and a mind that only represents it; instead, he writes that "Matter, in our view, is an aggregate of 'images'" (Bergson 1911, vii). This grounds the installation's audiovisual traces as part of the material situation itself (light, shadow, sound, texture, sensor thresholds), not a representation that stands apart from the room. Erin Manning extends this into a more explicitly durational account of movement, where time is not an external container, but something generated through relation. She writes, 'Movement takes time. But movement also makes time' (Manning 2009, 18).

Manning's durational account of movement becomes a direct bridge to the decay/trace system: if movement makes time, then interaction cannot be reduced to instantaneous trigger-response. What matters is how gestures carry on—how they stretch into afterimages, echoes, and slow dissipations that reorganize what a later body can feel. Manning names this relational temporality through the interval: "The interval is duration expressed in movement" (Manning 2009, 17).

In *Synaptic Echoes*, the "interval" is designed as a shared, atmospheric in-between: the system's fading visuals and lingering audio function as the atmospheric medium which participants sense that they are entering an already-moving ecology.

Barad helps name these traces as material histories rather than aesthetic decoration. Rather than treating memory as something stored "inside" a system, her framework supports reading memory as distributed across the material conditions of the event.

This is the move I try to make in the installation: memory is not stored "inside" the system as a private archive; it is written into the space as a temporary configuration of light, sound, and sensor-driven behaviour, an embodied inscription that the next person encounters as atmosphere. Barad's account is crucial here because it helps frame decay as a temporal condition of relation: traces do not persist as ownership, and they do not disappear as if nothing happened.

This is also why the work cannot rely on clock-time as a neutral measure. Barad insists: "Time is not a succession of evenly spaced individual moments" (Barad 2007, 180). Instead, time is produced through ongoing relations, what she elsewhere describes as the way "space, time, and matter are iteratively produced and performed" (Barad 2007, 393).

In my design, this becomes a technical commitment: decay functions in the visual and audio systems are not just "timers," but dynamic envelopes shaped by encounter: how long someone stays, how intensely they move, and how accumulated traces shift the next output state from one encounter to the next. The installation therefore behaves less like a replay machine and more like a river: always the "same" space, but never the same water.

Barad's image of material inscription helps articulate what a trace *is* in this project. She writes, "As the rings of trees mark the sedimented history of their intra-actions" (Barad 2007, 180). I take this as an anchoring metaphor for an installation that retains traces without archiving them: traces are sedimented for a time, then reworked by new presences. In this way, *Synaptic Echoes* invites a form of attention that is both intimate and humble: you can see the residue of others before you, and you can feel your own trace enter the system while knowing it will fade and make room for what comes next.

Donna Haraway extends this argument by framing relation as situated, partial, and ongoing rather than total or self-contained. In *Staying with the Trouble*, she writes, "Nothing is connected to everything; everything is connected to something" (Haraway 2016, 31).[1] This is useful for *Synaptic Echoes* because the installation does not remember as a complete archive, and it does not hold every encounter equally. It

[1] Donna J. Haraway, "Tentacular Thinking: Anthropocene, Capitalocene, Chthulucene," in *Staying with the Trouble: Making Kin in the Chthulucene* (Durham, NC: Duke University Press, 2016), 30–57. Haraway's broader project is to describe ongoingness, entanglement, and more-than-human relations without reducing the world to human-centered narratives of mastery or control.

remembers through specific contacts: a body moving through the room, a hand pressing the core, a sound that lingers, a visual field that carries residue forward. Memory here is not universal storage. It is a local and relational trace formed through contact and changed through time.

Haraway's idea of a "thick present" is also important here. She argues for staying with ongoing conditions of living and dying rather than treating time as a clean line that simply moves forward. This helps me name decay in the project. Decay is not the failure of memory, and it is not simple disappearance. It keeps the system open by preventing traces from remaining fixed: they soften over time so that new encounters can enter, overlap, and alter what remains. In this sense, *Synaptic Echoes* does not preserve the past intact. the past remains active for a while, then loosen its hold, making memory a temporary condition of relation rather than a fixed record.

## Human-Machine Interaction

Human-machine interaction in *Synaptic Echoes* is not organized around the familiar logic of input and output. The installation does not behave as a tool awaiting instruction, or as an interface that mediates between human intention and machine response. Instead, it operates as a mode of co-presence: a technical body that participates alongside human bodies through sensing and time-based modulation. Presence is registered as continuous change, such as proximity, touch, and sound levels, and these signals are shaped through thresholds, decay, and feedback so the work responds over time rather than as a single command.

This relational orientation draws from posthuman and new materialist thought, which challenge the separation between human and technological bodies and foreground the ways entities emerge through relation rather than in isolation. Barad's concept of intra-action is particularly relevant here. Barad specifies intra-action "in contrast to the usual 'interaction,' which presumes the prior existence of independent entities/relata" (Barad 2011, 125).

Paul Dourish's account of embodied engagement supports this framing through practice: meaning is produced through what people do in an environment, not delivered as a message from system to user. In the installation, participants learn the space by testing thresholds—how distance shifts the sound bed, which gestures thicken the image, and how long traces persist before they fade. (Dourish 2001, 126; Manning 2009, 15).

## Embodied Interaction & Cybernetics

Embodiment is central to how *Synaptic Echoes* understands interaction. The installation responds to bodies as they move, so interaction happens through a feedback relation: sensor readings shift the audiovisual field, and that shift conditions how participants move next. Dourish treats embodied interaction as grounded in embodied, situated practice rather than abstract representation (Dourish 2001, 102, 126).

*Synaptic Echoes* enacts this materially: it does not interpret bodies as intentions but responds to changing signals over time. Participants came to understand the work through repeated interaction: they tested movement, pause, and touch against the system's responses, gradually recognizing how their presence shaped the installation. In user testing, some repeated gestures to watch particle traces linger and disperse, while others learned that pressing the tactile object intensified light and heartbeat sound. Understanding emerged not as a fixed meaning, but through sensing patterns of response over time.

This lineage extends back to early interactive and cybernetic art, where responsiveness emerged through feedback. In *Artificial Reality II*, Myron W. Krueger describes environments in which participants gradually discover the relation between their movements and the system's visual response; the feedback continues only while the participant keeps moving, making bodily action necessary to sustain perceptual change (Krueger 1991, 48). Krueger also notes cybernetic sculptures that responded to viewers, including Edward Ihnatowicz's *Senster* (1970)[2] which oriented toward people's voices (Krueger 1991, 242).

*Synaptic Echoes*, retains changing patterns through time, so prior interaction can shift later thresholds and pacing. This temporal persistence matters most when interaction is collective. The system does not isolate a single user. It registers multiple bodies at once, where movements overlap and presences interfere. This is better described through Barad's intra-action than through a one-to-one model of interaction. As Barad states, "separately determinate entities do not pre-exist their intra-action" (Barad 2007, 174). In this view, "the existence of sender and receiver follows from this nonlocal relation rather than preceding it" (Barad 2011, 130). For *Synaptic Echoes*, the participant, the sensing apparatus, and the room are not separate terms that then interact. They take shape through the event as a shared field of sensing and response.

This also helps keep the writing precise about "human-like interaction." Suchman notes that insisting a system should conduct a dialogue "in as human-like way as possible" is contested and can defer the question of what human interaction comprises (Suchman 2007, 40–41). For *Synaptic Echoes*, the goal is not human likeness; it is felt consequence and temporal persistence inside a shared environment.

## Influences

While *Synaptic Echoes* is informed by affect theory, relational ontology, and embodied interaction, it is also shaped by artistic practices that use sensing and feedback to build relational environments. I do not treat these works as direct precedents, but as companion works that help clarify what it can mean for a technical system to register presence, change over time, and shape an encounter.

[2] In addition to responding to people's voices, the Senster also responded to their movements, which it detected by means of radar, and was (as far as I know) the first robotic sculpture to be controlled by a computer. It was unveiled in 1970 and remained on permanent show until 1974 when it was dismantled.

## Edward Ihnatowicz and early feedback sculpture

Edward Ihnatowicz's *Senster* (1970) is an early example of a responsive sculptural system whose behaviour changes in relation to human presence and sound. Krueger later described *Senster* as an animal-like sculpture that oriented its head toward people's voices (Krueger 1991, 212). A reactivation study describes how the work was designed to track and respond to sound and movement, noting that "loud sounds and sudden movements would repel Senster" (Olszewska and Długosz 2019, 8). Although *Senster* operated through direct sensing and response, its real-time adjustments gave it a lifelike quality for viewers. What matters for *Synaptic Echoes* is not the simulation of lifelike behaviour, but the sense that the system is responding in real time to the conditions of the encounter. Like *Senster*, the installation changes through proximity, movement, and the shifting dynamics of the space, so that behaviour appears to unfold through the relation itself rather than from a fixed sequence.

## David Rokeby and embodied interaction

David Rokeby's *Very Nervous System* (1986–1990) frames interaction as a feedback relation rather than a command structure. In *Very Nervous System*, Rokeby turned an empty room into a movement-based sound environment: a camera tracked bodily motion, custom image processing translated that motion into sound, and participants learned how to interact with the system by moving within it.[3] Rokeby writes, "A technology is interactive to the degree that it reflects the consequences of our actions or decisions back to us" (Rokeby 1995, 133)[4]. What matters here is not command, but legible consequence: participants discover how the system works through their interaction with it, then adjusting their movements to create new outcomes.

Rokeby observed that participants in an early version of *Very Nervous System* initially made gestures 'as a question to the space,' and only later, once they trusted the feedback, repeated those gestures 'as a command.' The system, he notes, did not interpret motivation; it 'merely reflected what it saw. This is what resonates with my own process in *Synaptic Echoes*. I am not trying to build a system that recognizes intention in a cognitive sense. What matters is creating a sonic environment in which participants can hear the consequences of movement in real time, evaluate those consequences through repetition, and gradually discover a responsive relation between body, sound, and space.

## Lozano-Hemmer and collective atmospheres

Rafael Lozano-Hemmer's work is useful for thinking about how interaction becomes collective and atmospheric. *Pulse Room* fills a dark exhibition space with rows of hanging incandescent bulbs, and a participant places their hands on a sensor interface that measures heartbeat and sends it into the light

[3] The Robert McLaughlin Gallery, "David Rokeby: *Very Nervous System*," exhibition page

[4] David Rokeby, "Transforming Mirrors: Subjectivity and Control in Interactive Media," in *Critical Issues in Electronic Media*, ed. Simon Penny (Albany, NY: SUNY Press, 1995), 133.

array. In the technical manual for *Pulse Room* (2006), he describes how participants heartbeats are added to the system, "pushing ahead all the existing recordings," so the room holds a queue of recent bodies (Lozano-Hemmer 2006, 2).

In *Zoom Pavilion* (2015), the system explicitly registers multiple bodies at once. *Zoom Pavilion* is an immersive surveillance-like environment with projections across three walls, fed by multiple computerized camera systems that track and magnify visitors in real time. The project description states that it uses "face recognition algorithms to detect the presence of participants and record their spatial relationship within the exhibition space" (Lozano-Hemmer 2015, 3). Later in the manual, Lozano-Hemmer explains that "when two people are detected, a relationship between them is established," and the camera behaviour shifts accordingly (Lozano-Hemmer 2015, 15). This is relevant to *Synaptic Echoes* because the installation is not conceived as a one-to-one interaction between a single participant and a system.

*Synaptic Echoes* is intended to register co-presence and to allow multiple bodies to shape the environment together. This question of collective legibility became important in my own testing, where co-presence was most clearly perceived through the movement-based projection system. In practice, however, the REB testing showed that this was most legible through the movement-based projection system, which drew the most attention and most clearly supported shared image-making. Other elements, especially the tactile object, were less strongly integrated into this multi-person interaction.

### Synthesis

Across the theoretical and artistic lineages explored in this review, a shared orientation emerges interaction is not a transaction but a relation, less a command than an unfolding "with" that reconfigures what counts as agent, action, and outcome (Barad 2011, 125; Suchman 2007, 71–72).

Synaptic Echoes is a space where bodies, human and nonhuman, meet through incipient shifts, co-create through distributed agency, and leave behind traces that shape what comes next (Manning 2009, 14, 32; Simondon 2017, 21; Barad 2007, 33). These ideas became most legible in the installation when participants first oriented through sound and projection, then gradually learned the work through delayed traces, lingering visuals, and shared image-making. Participants often described the interaction as conversational, relational, or give-and-take rather than fully controlled, which suggests that the installation was experienced less as a command system than as an unfolding responsive environment.

## Chapter IV. Methodology

This project is situated within a research-creation methodology as outlined by Owen Chapman and Kim Sawchuk. They note that research-creation projects "integrate a creative process, experimental aesthetic component, or an artistic work as an integral part of a study" (Chapman and Sawchuk 2012, 5).

They describe four modes of research-creation: research-for-creation, research-from-creation, creative presentations of research, and creation-as-research (Chapman and Sawchuk 2012, 5).

*Synaptic Echoes* draws most strongly on creation-as-research and research-from-creation because both maps directly onto my iterative, sensor-based installation practice. Chapman and Sawchuk describe creation-as-research as work 'where creation is required in order for research to emerge' (Chapman and Sawchuk 2012, 19). This aligns with *Synaptic Echoes* because the installation's central questions are investigated through making, tuning, and rebuilding the system as it behaves in real conditions. Research-from-creation supports the reflective side of this process. Chapman and Sawchuk describe it as 'an iterative process of going back and forth between creation and reflection or knowledge development' (Chapman and Sawchuk 2012, 20). In this project, building produces material evidence, while reflection guides the next set of design decisions.

Within this methodological frame, iterative design functions as a key method that structures the project's loop of prototyping, testing, documentation, and revision. The approach also draws on John Bowers' notion of the annotated portfolio, where documentation and reflection become part of the research process and how the work becomes intelligible. As Bowers writes, "An annotated portfolio is a pragmatic thing" (Bowers 2012, 72). In *Synaptic Echoes*, each prototype is documented through images, diagrams, short descriptions of sensing logic, and notes on what changed in participant interaction and system behaviour. Rather than treating prototypes as steps toward a final product, this approach treats each iteration as a site of knowledge that clarifies how the system's behaviour—and participants' responses to it—develop.

## Conceptual Framework

The conceptual framework for this research is organized around five concepts developed earlier in the thesis: attunement, agency, time, memory, and co-creation. In this chapter, I treat these concepts as both analytic lenses and design constraints. They shape decisions about what the system senses, how it responds, how long changes persist, and how the installation supports shared experience without collapsing interaction into a single action-and-response exchange. Put simply, this conceptual framework connects the project's theoretical concerns to concrete design decisions in the installation Research-as-creation.

The research-as-creation phase treats making as the primary mode of inquiry. Through iterative prototyping, coding, and fabrication, I test how sensor-based systems mediate encounters between bodies and the responsive installation environment. This includes experimenting with depth sensing, touch and pressure interfaces, microphones, and timing and memory logic, then observing how these technical choices shape attention, movement, and affective sense-making in the room.

This work moves through a repeating loop: plan, make, probe, analyze, reframe, and build the next iteration I use probes to isolate one variable at a time—for example, adjusting a threshold, smoothing value, latency, or decay rate— then observing how that change reshapes interaction.

So far, this process has taken place primarily through informal studio trials, where I test the system through my own embodied engagement and feedback from peers. This process is later extended through formal user sessions under REB approval, where the same interaction questions are tested with a wider range of participants.

Material and structural choices have also been tested through iteration. In early trials, in early trials, I covered sensor-based sculptural forms with latex. This created strong associations that pulled attention toward what the object might represent rather than what it could do relationally. The surface was often read as skin-like, which made some participants more cautious and more interpretive in how they approached it. In later tests, simpler modular forms, such as fabric-wrapped foam volumes, supported more direct touch. People squeezed, leaned, and stayed with the interaction longer, which also produced steadier sensor readings and clearer patterns for tuning the system's response.

## Research-from-creation and Reflexive Practice

The research-from-creation phase focuses on reflection and articulation. Documentation such as studio journals, photographs, videos, patch versions, and notes from critiques is the material for analysis. By revisiting documentation across iterations, I track how the installation's behaviour shifts in relation to the four concepts, especially how agency is distributed across bodies and system constraints, and how time and persistence shape what participants encounter.

This reflective layer draws on Bowers' annotated portfolio model[5], where each iteration is accompanied by commentary on what changed and why (Bowers 2012, 72). Feedback from SPARK critiques[6] (Fall, 2025) and the Graduate Colloquium is also folded into this process, prompting shifts away from novelty and toward relational clarity, and away from single-user interaction toward multi-bodied presence.

## System Architecture

The technical architecture of *Synaptic Echoes* translates human presence into spatial sound, light, and material change through a layered system of sensing, processing, memory, and response. This architecture is not simply a technical support structure It is designed to support the project's conceptual concerns: relational sensing, distributed agency, temporal layering, and co-creation. (Figure 7)

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[5] Bowers, John. 2012. "The Logic of Annotated Portfolios: Communicating the Value of 'Research Through Design.'" In Proceedings of the Designing Interactive Systems Conference (DIS '12), 68-77. New York: ACM.

[6] SPARK is a critique show for OCAD University Digital Futures graduate students, typically held in late October, where students present early thesis prototypes and works in progress for feedback.

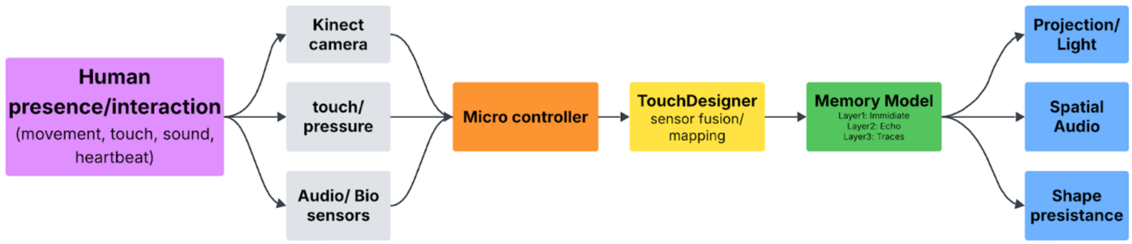


*Figure 5. System Architecture Diagram which summarizes the overall flow*

## Sensing Layer: From Presence to Signal

The sensing layer begins with presence in the room: movement, proximity, touch, breath, and bodily gesture. These are not treated as isolated triggers. They are treated as continuous activity that the system samples through multiple sensing modalities. Here, signal refers to measurable sensor readings and derived values that register what is happening in the space. A Microsoft Kinect v2[7] captures depth and body-position information, allowing the system to register where bodies are in space and how they move.

Touch and pressure sensors embedded in the deformable, the sculptural object register contact, weight, and intensity of tactile engagement. Presence and environmental sensors, including mmWave[8] radar and a microphone register ambient sound, small motions, and micro-variations that contribute to the sense of presence. Each sensor offers only a partial view. Taken together, they allow the system to register patterns of activity across the room.

## Processing Layer: Microcontroller and TouchDesigner

Sensor data first passes through a microcontroller, which handles low-level tasks such as reading analog and digital signals, normalizing values, and packaging them into a serial data stream. This step reduces the complexity of raw signals and formats the data so it can be interpreted consistently.

The encoded data is then sent via serial connection to TouchDesigner, which serves as the central processing and composition environment. Inside TouchDesigner, signals from the Kinect, pressure sensors, and audio or environmental sensors are combined into higher-level descriptors such as body density, intensity of touch, and overall activity. These descriptors are then mapped into parameters that affect sound, light, projection, and memory states. Behaviour logic defines how the system responds across

---

[7] Microsoft Kinect v2 is a depth-sensing camera system that combines an RGB camera, an infrared emitter, and a depth sensor, allowing the installation to register body position, movement, and spatial depth in low-light conditions.

[8] mm Wave refers here to a millimeter-wave radar sensor used for presence detection and small-motion sensing. Unlike a camera, it detects subtle bodily movement, such as stillness, micro-motion, or breathing-related motion, without requiring visible light or physical contact.

Microsoft, *Kinect for Windows Human Interface Guidelines v2.0* (2014).

different temporal phases: immediate response, temporal echo, and long-term trace. This processing layer is where sensed activity becomes system behaviour. Measurements of presence are transformed into usable patterns that shape the installation environment.

### Memory Model: Immediate, Echo, and Trace

At the core of the architecture is a memory model that gives duration and atmospheric persistence a technical form, the immediate layer produces direct, real-time responses to current sensor activity. Small movements or touch, trigger immediate changes in sound or light. This supports attunement by making relations of action and response perceptible in the moment.

The echo layer produces short-term temporal reflections that reintroduce earlier gestures after a delay. For example, a gesture may return as a faint sonic or visual echo a few seconds later. This layer prolongs the present, allowing actions to resonate beyond the moment they occur.

The trace layer produces longer-term accumulations that persist across encounters or extended periods of activity. Rather than storing exact events, this layer retains changing patterns such as overall intensity, frequency of visits, and zones of repeated contact. These traces shape background behaviour, influencing the ambience even when no one is actively engaging the system.

In implementation terms, these layers are realized as separate but connected processes inside TouchDesigner and through the sculpture's material behaviour, each with its own logic of fading, persistence, and accumulation. Conceptually, they allow the system to register the past at multiple temporal scales, turning memory into an active part of interaction rather than a static archive.

### Response Layer: Spatial Experience

"The final stage renders the system's internal state as a spatial experience in the room. Spatial audio forms multi-channel sound fields that respond to body position, density of presence, and memory states. Projection and light generate visual patterns, and intensity shifts that express both immediate interaction and longer-term traces. Shape persistence occurs through the deformable, sculptural object, which retains physical traces of touch and pressure between encounters and operates as a material memory surface.

These responses do not operate as separate channels. They operate as one sensory ecology. Sound, light, and material deformation draw from the same sensing and memory logic, making the system's temporal structure perceptible Participants do not need to see the architecture directly. They encounter it through how the system behaves over time.

# Chapter V.
# Prototyping

In *Synaptic Echoes*, prototyping functions as a way of asking and testing design questions through making. Each prototype is an exploratory artifact used to test a design question and generate responses that guide the next iteration (Sanders and Stappers 2012, 301).

This aligns with research-creation, where research-creation projects "integrate a creative process, experimental aesthetic component, or an artistic work as an integral part of a study" (Chapman and Sawchuk 2012, 5). Within this approach, making is not separate from thinking. As Chapman and Sawchuk note, keeping track of process enables 'an on-going iterative process of experimentation, and of trial and error' (Chapman and Sawchuk 2012, 16).

To document each iteration, I adapt Gibbs' structured reflection sequence—description, feelings, evaluation, analysis, conclusions, and action plans—into a repeatable template for prototyping notes (Gibbs 1988, 48–49). This documentation approach also draws on Bowers' annotated portfolio logic: the same body of work can be annotated differently depending on purpose and audience (Bowers 2012, 71), and the portfolio can function as a practical research form rather than an abstract archive (Bowers 2012, 72). The prototypes that follow are organized as iterative studies, each documenting a design question, the process used to test it, the observations that emerged, and the decisions that shaped the next iteration.

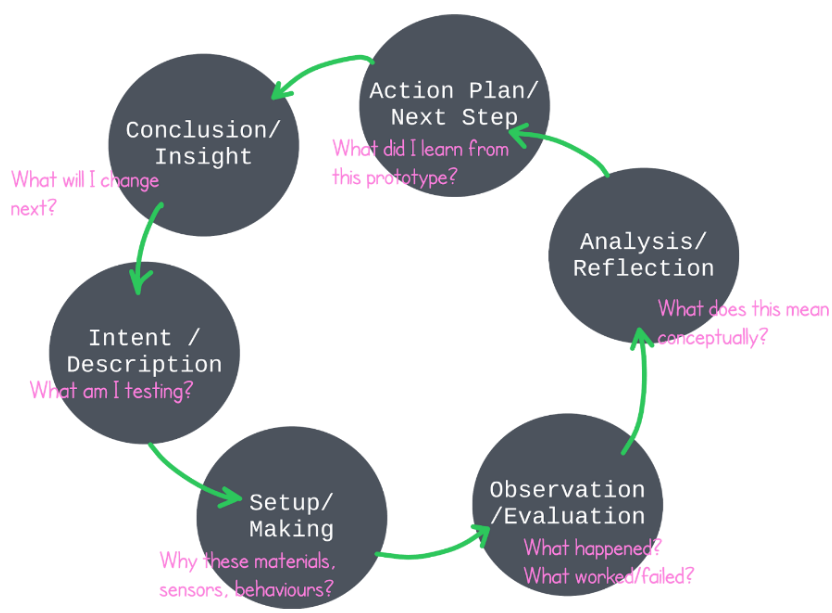


*Figure 6. Prototyping Method Cycle (Adapted from Gibbs' Reflective Cycle, 1988)*

## Prototype 1. Material Affordances and Pressure Interaction

“This series of tactile sensor prototypes explored how varied materials invite touching, squeezing, and handling. The guiding question for this iteration was: How do materials shape relational entry points into the system?

I built six tactile enclosures, each embedding an FSR pressure sensor inside a different material: silicone, wool, soft foam, a balloon filled with jellybeans, fidget balls, and fabric-wrapped forms. I documented each build through short notes and photographs in the process journal (Appendices A., Sept. 21)[9]. This prototype was treated as an exploratory probe, used to learn what kinds of touch the materials invite and what kinds of interaction they resist.

*Figure 7. Early material prototypes for pressure interaction (FSR embedded in silicone, wool, foam, balloon with jellybeans, fidget balls, and fabric-wrapped forms).*

Testing showed that each material produced a different pattern of use and response. Foam was the most consistent in readings and encouraged quick, repeated presses. Silicone produced intense pressure response and sustained squeezing, but it was difficult to reopen and adjust. The balloon with jellybeans invited playful handling, but the sensor readings were unstable. Wool was approached gently and produced moderately consistent readings. Participants approached foam and wool without hesitation but treated silicone more cautiously. Balloon-based forms drew attention quickly but were difficult to rely on across repeated tests.

These tests supported a central insight for *Synaptic Echoes*: the object should remain familiar and non-threatening, so participants can focus on interaction rather than trying to interpret what the object is.

[9] Date: Sept. 21, Appendices A.

This aligns with feedback from SPARK and Graduate Colloquium sessions, where materials with a stronger representational or object-like presence pulled attention away from the relational behaviour of the system. In other words, material choice functions as an entry condition for relational engagement and co-creation, shaping whether participants approach quickly, cautiously, or not at all.

Based on these results, I used foam and wool for stable early iterations. The next prototype will move toward a multi-sensor array and begin integrating temporal behaviour so the system can carry traces forward rather than responding only in the moment.

## Prototype 2: Sound Mapping and Time as material

This prototype tested how pressure input could translate into sound behaviour, and whether sound could act as the main affective feedback channel. I also evaluated duration-based behaviour to see how time can become part of the interaction. The guiding question for this iteration was: *How does bodily pressure become an expression? What forms of sonic responsiveness support attunement rather than instrumentality?*

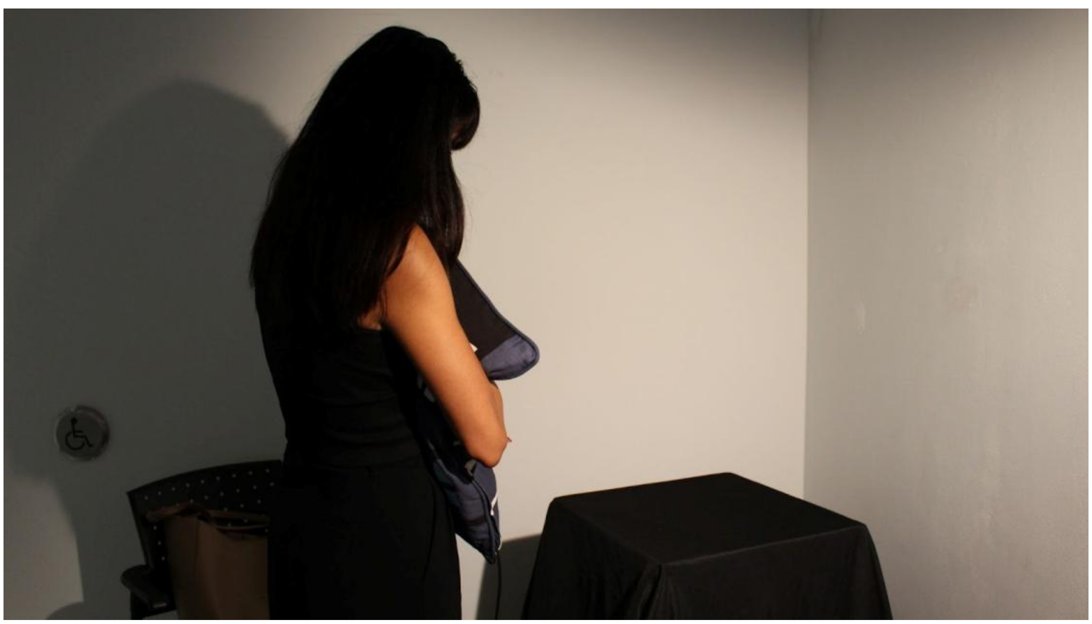

*Figure 8. Presentation for SPARK, prototype, pressure sensor in a pillow-shaped object to trigger sound.*

To evaluate the tactile materials as interactive interfaces, I first wrote a simple DIY pressure-reading sketch for the Arduino Nano 33 IoT[10], designed to output a stable value suitable for real-time mapping. The initial version focused on a single FSR[11] input: the analog signal was read at 10-bit resolution (0–1023)[12], smoothed using an exponential moving average to reduce jitter, and stabilized further by calculating a slow-moving baseline so that small drift in the resting value would not register as "touch." A small dead-zone threshold[13] was applied so that micro-fluctuations (noise) would output 0, while pressure above the threshold produced a normalized value (0–1) sent over serial.

```
// Nano 33 IoT — pressure p (0..1) ~200 Hz
const int FSR_PIN = A1;
float s=0, base=0;

void setup(){
  analogReadResolution(10);
  Serial.begin(115200);
  long sum=0; for(int i=0;i<32;i++){ sum+=analogRead(FSR_PIN); delay(2); }
  base = s = sum/32.0f;
}
void loop(){
  int r = analogRead(FSR_PIN);
  s     += 0.20f*(r - s);        // smooth
  base  += 0.01f*(s - base);     // slow drift follow
  float d = s - base; if(d<0) d=0;
  float p = d/150.0f;            // tweak 320 if needed for your press range
  if(p>1) p=1; if(p<0.03f) p=0;  // dead-zone
  Serial.println(p, 3);          // <-- JUST the number
  delay(5);
}
```

*Figure 9. Arduino Nano 33 IoT pressure-sensing sketch used to stabilize FSR input through smoothing, baseline drift compensation, and dead-zone thresholding before sending normalized values over serial.*

After validating the approach with one sensor, I expanded the sketch to read six analog inputs (one per material enclosure), outputting six pressure values per frame. This shift was necessary because the core question was comparative: the goal was not simply to detect pressure, but to observe how varied materials produce different touch behaviours *in parallel*.

During testing, I noticed that the readings for sensors on pins 4, 5, and 6 were more unstable (floating/noisier) than the others, especially at rest. Rather than treating this as a single "bug," I treated it as an interaction-design constraint: each enclosure had a different baseline range and noise floor due to material compression, contact consistency, and sensor seating. I therefore applied sensor-specific thresholds (and, where needed, slightly different scaling) so that each channel would only activate when

---

[10] Arduino Nano 33 IoT is a compact microcontroller board used here to read sensor input and send processed values to the main system in real time. It supports analog input reading and serial communication, which made it suitable for prototyping tactile interaction.

[11] FSR stands for Force Sensing Resistor, a pressure-sensitive sensor whose resistance decreases as more force is applied. In this project, it was used to translate touch and pressure into changing analog values.

[12] A 10-bit analog reading represents input values across 1024 steps, from 0 to 1023. In this project, that range provided a simple way to measure changes in pressure and map them into normalized values for interaction.

[13] A dead-zone threshold is a small cutoff range below which sensor values are treated as zero.

the touch was intentional, not when the input drifted or floated. This made the six sensor channels comparable as interaction signals rather than comparable only as raw voltages.

### TouchDesigner: Serial Intake, Channel Separation, Audio Volume Mapping

Once the Arduino output was stable, I moved into TouchDesigner to test real-time feedback as an early form of "relational response." The serial stream was received through Serial DAT[14], parsed into tabular data, and then transformed into continuous channels using DAT to CHOP[15]. From there, I used a Resample CHOP[16] and Filter CHOP[17] to smooth the stream further and reduce audible stepping when mapped to sound.

To keep the system legible and modular, I separated each sensor into its own channel using Select CHOP[18] (FSR1–FSR6). Each channel was then shaped with a Math CHOP[19] to match the desired response curve for audio control, primarily scaling and clamping values to a clean 0–1 range appropriate for gain/volume modulation. (Figure 10)

*Figure 10. TouchDesigner prototype network for receiving six-channel pressure data via Serial DAT, converting it into CHOP signals, and routing each sensor channel into an audio feedback chain.*

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[14] Serial DAT is a TouchDesigner operator used for serial communication through an external port

[15] A TouchDesigner operator that creates CHOP channels from values contained in a DAT (CHOP stands for Channel Operator)

[16] Resample CHOP changes the sample rate and/or interval of incoming channels.

[17] Filter CHOP smooths or sharpens input channels by combining each sample with neighboring samples.

[18] Select CHOP retrieves specific channels from one or more CHOPs and can also rename them.

[19] Math CHOP performs arithmetic operations on channels and can scale, offset, or remap input values into a desired range.

*Figure 11. TouchDesigner signal conditioning and channel separation: serial data converted to CHOP, smoothed with Resample and Filter CHOPs, split into FSR1–FSR6 using Select CHOP, then scaled/clamped with Math CHOP for audio volume control.*

This patch allowed each material enclosure to function as a distinct input voice, where pressure intensity could directly control the audio volume of a corresponding sound layer. In this early stage, the mapping was intentionally simple: I used audio as immediate feedback to quickly evaluate how each material encouraged different touch rhythms (quick tapping vs. sustained squeezing) and how reliably those gestures could be translated into stable system behaviour.

Participants quickly understood the mapping of more pressure to louder sound. The dead-zone reduced accidental activation and removed jitter when hands hovered near the threshold. Smoothing reduced rapid fluctuations that made the system feel unstable. When two sensors were pressed at once, overlapping sounds produced surprise and curiosity, and some participants described the system as “alive” when layers accumulated.

Participants understood the first layer of interaction, where pressing caused Sound A. The delayed shift encouraged them to keep contact longer, and some began to experiment with holding, releasing, and reapplying pressure to test what the system would do next. Micro-latency and the shape of the crossfades changed the emotional tone of the transition.

Sound functioned as an affective channel that participants responded to before they could explain what they were doing. This supported my decision to treat sound as a core expressive material for the project. Massumi’s distinction between affect and emotion helps clarify why this worked: sound registered first as intensity and only later became something participants could describe in words, such as tension, anticipation, or release (Massumi 2002, 27).

The time-based hold-to-shift behaviour also changed the interaction from immediate response to durational negotiation.

This prototype clarified a design constraint: stability is part of relational trust. When the sensor signal was noisy, participants treated the system as unreliable. When smoothing and thresholds produced consistent transitions, participants stayed longer and tested variation. The logic developed here became a first step toward the later memory model, where interaction is shaped by persistence and change across time rather than only momentary input.

## Prototype 3: Visual Co-Presence and Spatial Sensing

After focusing on material and sound in earlier prototypes, this iteration turned toward visual presence and spatial sensing. The guiding question was: How can body movement and, later, skeletal tracking shape generative visuals in an immersive, low-light space? This prototype tests how the system can register bodies in the room and translate that presence into visual behaviour. It extends the research-creation process from tactile and sonic interaction into visual co-presence, where motion is not only detected but rendered as atmosphere and relational feedback.

I approached this prototype in two stages: (1) a webcam-based MediaPipe hand-tracking study[20] built in TouchDesigner to prototype gesture-to-visual mappings quickly, and (2) a transition to Microsoft Kinect v2[21] once the project shifted toward low-light projection conditions.

### Stage 1: MediaPipe Hand Tracking as a Gesture-Control Practice

Before moving to full-body sensing, I built a small MediaPipe hand-tracking pipeline using a standard webcam input into TouchDesigner. As a first exercise, I reduced the tracking to two points, the index fingertip and the thumb, and designed a simple, legible gesture language to test how subtle hand motion could function as an embodied control interface. The core control signal was the distance toward a pinch (short distance), the moving blocks became noisier and more pixelated. When the fingers moved farther apart (higher distance), the image returned toward a cleaner state. This pinch-distance mapping became my first working model for how embodied movement could tune the visual atmosphere without requiring explicit buttons or menus. between the thumb and index finger, mapped as a continuous scale

[20] Google, "Hand landmarks detection guide," *Google AI Edge*, accessed March 13, 2026. MediaPipe is Google's framework for machine-learning-based perception tasks.

[21] Microsoft Kinect v2 is a depth-sensing camera system used here for low-light spatial sensing.

value. When the fingers closed. During the MediaPipe/webcam stage, gesture tracking and responsive visuals were strong in stable lighting. The pinch-distance mapping produced a clear and learnable relationship between hand motion and image texture (noise/pixelation), and the rotation trigger supported state-change behaviour with audible confirmation. However, stability dropped sharply in low light, causing jitter and loss of tracking.


*Figure 12. (left) MediaPipe hand-tracking test in TouchDesigner showing thumb–index pinch distance ("Scale") used as a continuous control signal. (right) Generative block field under high-noise condition produced by a closed pinch gesture (low thumb–index distance*


*Figure 13. (left) MediaPipe hand-tracking test showing an open pinch gesture (higher thumb-index distance) returning the system toward a neutral visual state. (right) Generative block field in a lower-noise/neutral condition produced by increasing thumb-index distance, stabilizing the moving forms.*

I also tested a second gesture: rotating/turning the index finger to the right as an intentional directional cue. When detected, this gesture triggered a re-seeding behaviour in the moving blocks (their positions reconfigured simultaneously triggered a brick-like impact sound as an audible confirmation of the transition. In this early stage, the purpose was not precision, but learnability: to build a feedback loop where the system's response was readable enough that users could discover it through play.


*Figure 14. Gesture-trigger test: rotating/turning the index finger to the right triggers a "Next" state change, re-seeding the positions of the moving blocks and activating a brick-like sound cue as confirmation.*

### MediaPipe/ TouchDesigner Signal Extraction (Implementation Notes)

In TouchDesigner, the MediaPipe hand-tracking stream was parsed into CHOP channels representing normalized landmark coordinates (x, y, z). I isolated only the landmarks needed for this gesture vocabulary using Select CHOP, focusing on the index fingertip and nearby joint (MCP) for directionality, alongside the thumb/index relationship for pinch distance. To stabilize the interaction, I used Hold CHOP nodes to reduce rapid flicker during micro-movements and applied clamping/mapping (Math/Clamp), so the control signals stayed within predictable ranges for visual modulation. A small script step computed the pinch-distance value (used to drive noise/pixelation) and extracted a simple directional cue from the index finger's orientation (used to trigger the "Next" state change and associated brick sound).

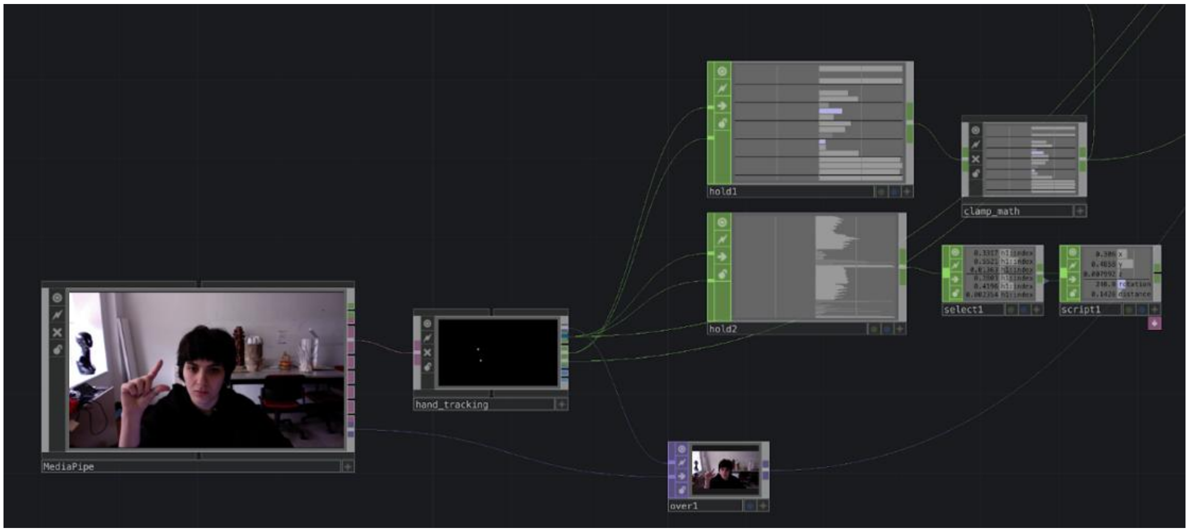


*Figure 16. TouchDesigner MediaPipe hand-tracking network used to extract landmark data and derive gesture control signals. The pipeline isolates hand landmarks, stabilizes the stream (hold), constrains values (clamp/mapping), and outputs computed parameters.*


*Figure 15. Select CHOP channel extraction from MediaPipe hand landmarks. The index fingertip and joint (MCP) coordinates (x, y, z) are isolated as a minimal dataset for gesture interpretation, enabling both continuous control (pinch-based scaling) and directional cues (index orientation) for triggering state changes.*

This MediaPipe practice was my first step toward an interactive visual system grounded in body movement: a minimal gesture set (pinch + rotation) that demonstrated how motion could shape both image texture and system state change.

### Stage 2: Transition to Kinect v2 for Low-Light Embodiment

Once the installation was conceived as a dark projection environment, the webcam's limits became clear. Tracking quality dropped in low light, and instability disrupted the sense of co-presence. I shifted to Microsoft Kinect v2 because its depth sensing and skeleton tracking are less dependent on visible light. In TouchDesigner, I began working with the Kinect TOP for depth and image streams and the Kinect CHOP for skeleton data.

*Figure 17. TouchDesigner Kinect TOP set to (in left to right order) Color, Infrared and point cloud mode. Screenshot by author. The Kinect TOP provides selectable image streams (including Infrared and Depth) from Kinect v2 for use in low-light interactive setups.*

During the MediaPipe/webcam stage, gesture tracking and responsive visuals were strong in stable lighting. The pinch-distance mapping produced a clear and learnable relationship between hand motion and image texture (noise/pixelation), and the rotation trigger supported state-change behaviour with audible confirmation. However, stability dropped sharply in low light, causing jitter and loss of tracking.

After moving to Kinect, depth sensing proved more robust in darker conditions, and skeleton tracking felt more consistent across changing surface lighting. The trade-off was increased setup complexity and new calibration questions related to distance, field of view, and joint interpretation. The main observation so far is that sensing technology shapes what kind of spatial experience can be produced.

This prototype clarified that visual co-presence is inseparable from sensing infrastructure. Barad's account of phenomena supports this, since she describes a phenomenon as the "entanglement/inseparability of 'object' and 'apparatus' (which do not pre-exist the experiment but rather emerge from it)" (Barad 2011, 142). In this prototype, the visual behaviour is not an overlay added onto bodies-in-space. It is shaped by the apparatus that detects depth, joints, motion, and distance.

The move toward a dark projection environment also made clear that immersion has technical consequences. Low-light conditions pushed the work away from webcam tracking and toward depth sensing. This shifted embodiment from touch and pressure toward movement, proximity, and multi-body presence. Manning's account of space as produced through movement helps frame this shift: "My movement creates the space I will come to understand as 'the room'" (Manning 2009, 15).

In this sense, the prototype is not only generating visuals. It is testing how the room becomes legible through movement and through what the system can register.

## Prototype 4: Embodied Memory through Reactive Audio-Visual Feedback (*Synaptic Echoes* V1)

This prototype evaluated whether embodied interaction could support co-creation between humans and a technical system, with a secondary focus on whether gesture can generate a sense of shared memory within an audiovisual environment. Rather than treating the system as a passive interface or reactive tool, I framed it as a performative system that listens, responds, and changes through time. The prototype focused on how attunement might emerge as participants learn the relation between their bodies, sound, and visuals over time, and how agency can be shaped through responsive feedback rather than explicit control.

The system was built with TouchDesigner as the central environment, integrating Kinect v2 for body and hand tracking and Ableton Live for real-time sound synthesis and processing. The Kinect provided skeletal tracking with a focus on hand position in space. Each hand (left and right) was mapped along the X and Y axes to sound parameters in Ableton such as mixing levels, reverb, and delay. These mappings were intended to produce continuous sonic change rather than discrete notes.

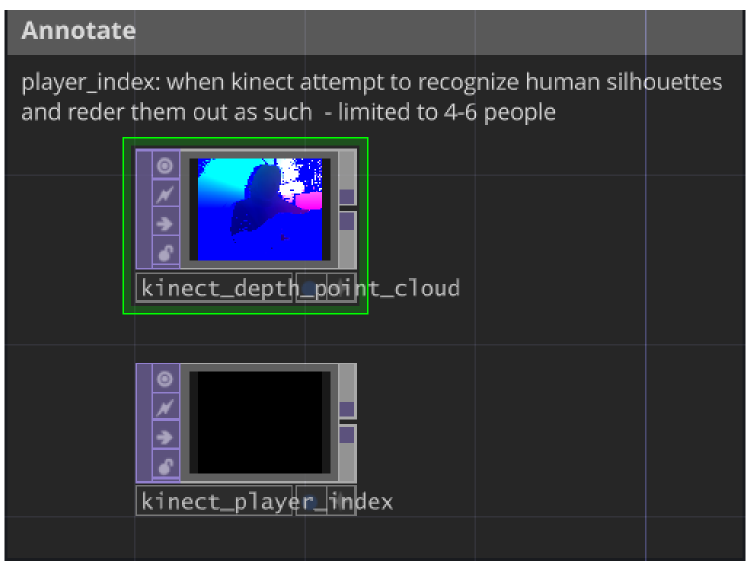


*Figure 18. Kinect TOP to capture depth point clouds.*

## Sound System Process (Kinect/ TouchDesigner/ Ableton Live)

To develop a durational "trace" logic in sound, I connected TouchDesigner to Ableton Live using the TDableton package, establishing a stable OSC-based communication pipeline between the two environments. Rather than following the more common workflow of driving visuals from audio analysis, I reversed the direction of influence: visual sensing (Kinect skeletal/hand data) became the primary control signal for sound synthesis and processing. This choice aligned the sonic layer with embodied co-presence, allowing movement in space to directly shape the acoustic atmosphere.

Within TouchDesigner, I extracted the X and Y axes of both left and right hand (Figure 21) positions from the Kinect skeleton stream and separated these into four continuous control channels (Left X, Left Y, Right X, Right Y). Each channel was routed into a dedicated TDableton/MIDI output so the values could be sent as musical control data into Ableton. In Ableton, I created four corresponding MIDI tracks (named after each hand axis) and designed each track as a distinct "voice" with different time-based effects, delay, reverb, sustain, and echo, so that movement would leave audible residues. This meant the system could continue sounding even when the participant became still: rather than stopping abruptly, audio would linger and fade, reinforcing memory as persistence and decay rather than as a stored record.

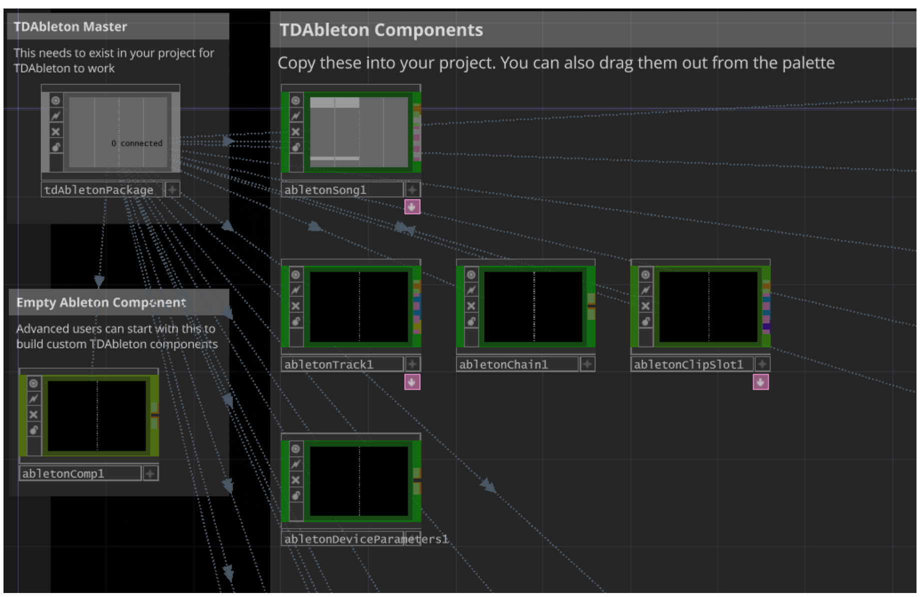


*Figure 19. TDableton package components inside TouchDesigner. TDableton Master and core Ableton components (song, track, chain, clip slot, device parameters) used to establish OSC communication between TouchDesigner and Ableton Live*

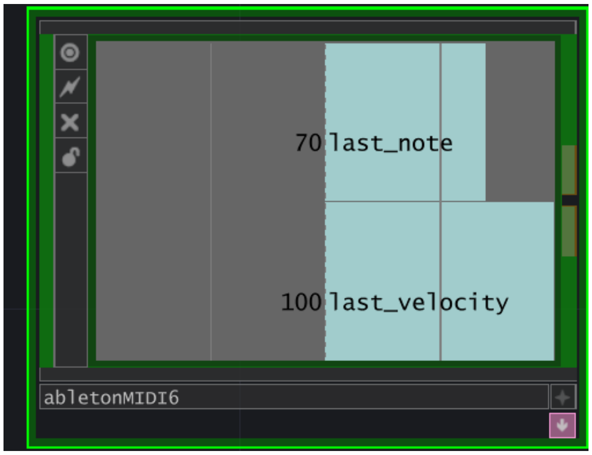


*Figure 21. Ableton MIDI output from TouchDesigner (monitoring note/velocity). AbletonMIDI CHOP displaying "last_note" and "last_velocity," used to verify stable conversion from continuous hand movement into discrete MIDI events.*

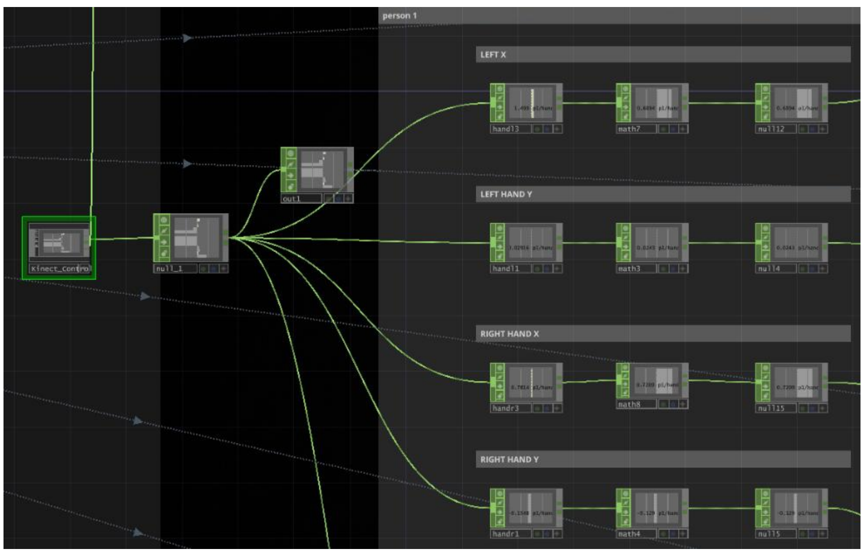


*Figure 20.Hand-axis extraction and routing in TouchDesigner. Kinect hand position data separated into four channels (Left X, Left Y, Right X, Right Y), then routed through processing and mapping nodes to prepare values for OSC/MIDI output.*


*Figure 22. Ableton Live session view with movement-driven MIDI tracks. MIDI tracks mapped to hand axes (Left Hand X/Y, Right Hand X/Y) receiving data from TouchDesigner and driving distinct sonic layers; meters show active modulation during gesture input.*

To expand the system from continuous parameter modulation into note-based articulation, I introduced a second layer of mapping: each axis range was segmented into small numeric bands, with each band assigned to a specific pitch (e.g., values between 0.20-0.23 triggering a particular note). This discretization allowed the body to "play" the system spatially. Because raw tracking data can fluctuate rapidly, I applied smoothing and constraint strategies to prevent unintended rapid note firing. In Ableton, the Scale MIDI effect was used to constrain output to a chosen musical mode, and monitoring tools confirmed that note and velocity changes remained readable and musically stable rather than chaotic. (Figure 25.)

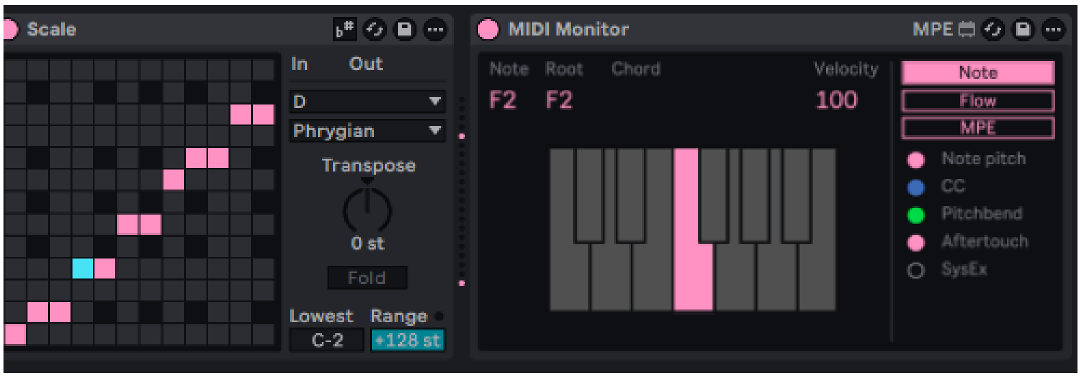


*Figure 23. Scale constraint and MIDI monitoring in Ableton Live.Scale MIDI effect used to quantize incoming movement-driven notes to a defined musical system, while MIDI Monitor confirms pitch and velocity output during interaction.*

### Visual System Process (Kinect / TouchDesigner / Particle Feedback)

To develop the visual language of this prototype, I worked with Kinect depth data inside TouchDesigner and translated that data into a particle-based representation of the body. I chose particles because they offered a straightforward way to make human presence visible through the sensor's point-cloud[22] logic rather than through a full photographic image. Instead of showing the participant as a solid figure, the body appears as a field of small points against a black background, shaped by depth information and constantly re-formed through movement.

This choice was both technical and conceptual. Technically, the Kinect already registers bodies through depth values and spatial coordinates, so working with particles allowed me to stay close to the way the sensor registers the body. Conceptually, the particle field made presence feel as though it was emerging from darkness rather than appearing as a complete image from the start. The body seemed to come into view through dispersed points of light, as if something were being formed from almost nothing and then returning to dispersion again. In practice, these particles often looked like stars gathering, drifting, and

[22] A point cloud is a set of spatial data points used to represent the surface of a form in three-dimensional space. In this project, Kinect depth data was used to produce a point-cloud-like body image, allowing the participant's form to appear as a field of discrete points rather than as a full photographic image. TouchDesigner' Kinect point cloud tools describe this process as generating a point cloud from depth textures and color data.

gradually fading away, which aligned strongly with my research interest in memory, trace, and temporal persistence.

Before building this visual system in TouchDesigner, I created an AI-generated moving image for my colloquium presentation to communicate the atmosphere I was aiming for: a human figure composed of particles in a dark space, with matter appearing to gather, trail, and dissolve over time. Although that image was not part of the working prototype itself, it helped me articulate the visual direction of the project and confirmed my interest in presence as something emerging, scattering, and lingering rather than appearing as a fixed body.

*Figure 24. AI-generated concept image created by the author using Midjourney for colloquium presentation. The image was used to visualize an early atmospheric direction for Synaptic Echoes.*

In TouchDesigner, I used Kinect depth information to generate a point-cloud-like body image and then shaped that image through a particle system. (Figure 27.) As the participant moved, new particles were emitted in relation to their body and gesture, allowing the figure to remain responsive while also fragmenting into an atmospheric field.

To extend this beyond immediate reaction, I introduced a feedback loop. In simple terms, a feedback loop works by sending the current frame of the image back into the system, where it is blended with the next incoming frame. Instead of each frame replacing the one before it, the image carries a

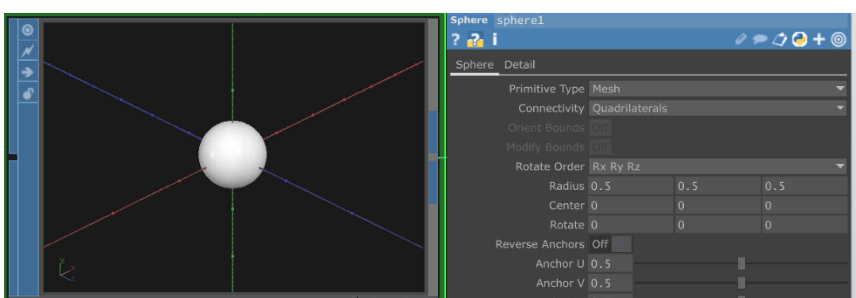


*Figure 25. POPs-based particle setup used as a presence engine. Reference setup demonstrating the POPs particle system as the visual substrate for presence, where emitter behaviour and transformation parameters are tuned to produce responsive motion while maintain*

reduced remainder of previous frames. By lowering the opacity or brightness of the returning image over time, older traces gradually fade rather than disappearing all at once. This made it possible for movement to leave behind visual residue: a gesture did not end in the same moment it was performed, but continued as a trail, smear, or faint atmospheric trace.

This feedback structure became the basis of the visual memory model in the prototype. The particle system produced an immediate layer of live movement, an echo layer of short-lived trails, and a trace layer of slowly fading residue. New movement entered the same field rather than starting from a blank screen, so the visual state of the system was always shaped in part by what had just happened. In this way, the image felt less like a representation of the body and more like a temporal record of relation unfolding in space.

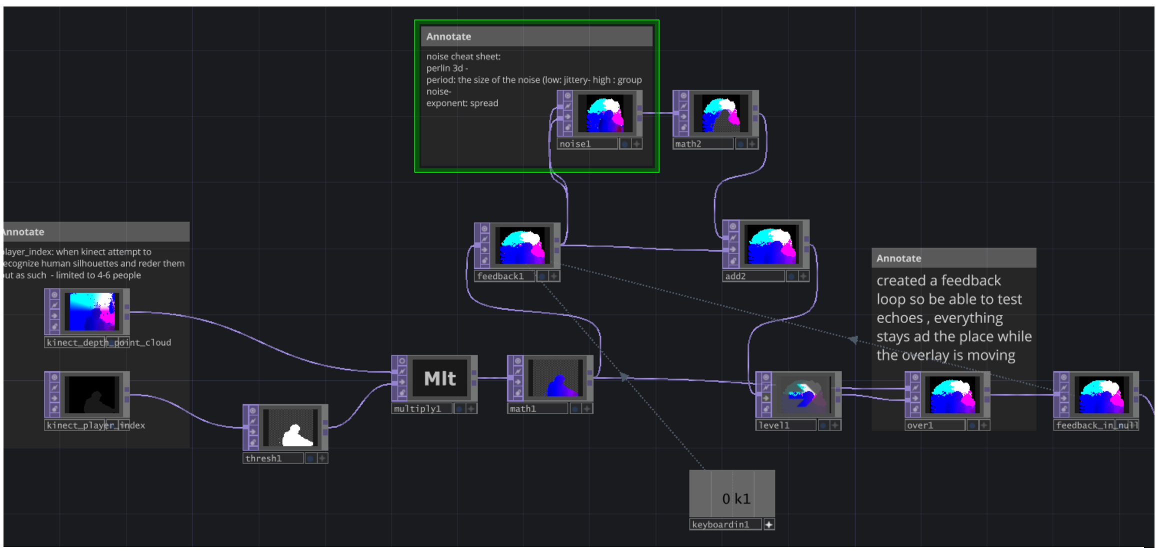


*Figure 26. TouchDesigner network for Kinect point-cloud masking and feedback persistence. Network fragment showing Kinect depth and point-cloud input, threshold-based body isolation, and a feedback loop used to accumulate and attenuate prior frames. The feedback path allows particles to persist beyond the moment of movement, supporting decay-based temporal behaviour.*

*Figure 27. Kinect-driven particle body image generated from depth point-cloud data. The participant's body is rendered as a field of particles against a black background, showing how depth information is translated into an atmospheric visual form rather than a full photographic image.*

A similar logic was applied to sound through delay, reverb, and sustained tails, so that both the visual and sonic layers operated through persistence and decay. In this way, the prototype began to treat memory not as storage, but as the continued influence of prior interaction on what the system could do next.

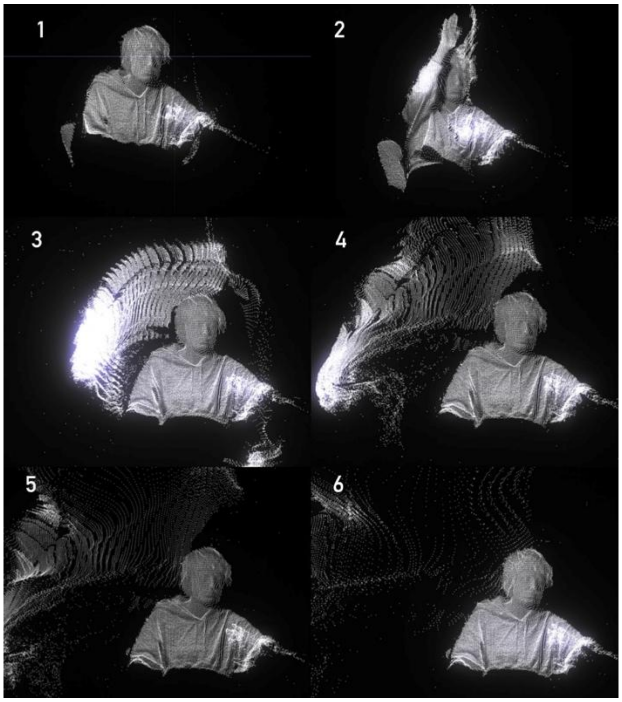


*Figure 28. Particle persistence and decay across time (six-frame sequence). Sequential frames of the Kinect-driven particle field showing how movement generates dense particle clusters (immediate response), which then stretch into short trails (echo) and gradually dissolve into a low-intensity atmospheric residue (trace). New gestures accumulate into the same field, producing interference between fresh input and fading traces.*

Initial testing was conducted with myself, my advisors, peers, and one participant unfamiliar with the system. Most participants entered without a clear sense of where to begin. This suggested the need for a subtle cue, such as a dim light cue, a proximity trigger, or a quiet baseline sound that shifts when someone enters. Because the visuals were projected on a single wall, participants positioned themselves facing the projection. This produced a mirror-like relation between movement and response. It supported reciprocal feedback but also kept engagement frontal, which raised questions about how to distribute interaction throughout the room.

The Kinect captured multiple bodies visually, but hand tracking was limited to one participant. This created an unexpected division of roles: one participant could dominate sound while multiple bodies contributed to the visual field. Participants were drawn to the particle behaviour and the way traces lingered and dissolved. Advisor feedback suggested increasing the duration of persistence to make the memory logic more legible. One participant, Male (27), described the experience as playful and "enchanting," and expressed a desire to "draw" with his body. He experimented with gestures that produced wings, inversion, and exaggerated arm movements. He also wanted a wider range of meaningful gestures beyond swaying, suggesting a need for richer movement vocabulary. (Figure 31.)

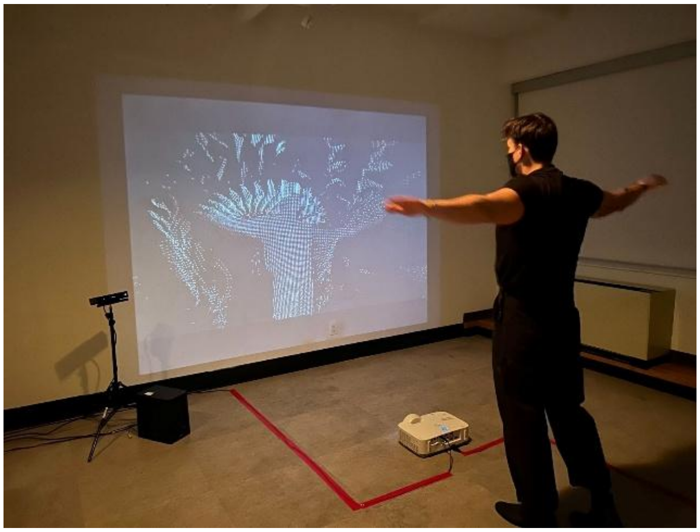

*Figure 29. Participant interacting with* Synaptic Echoes *in front of the projection. The images show the frontal, mirror-like relation produced by the single-wall projection setup, in which bodily movement generates both immediate particle response and lingering visual residue.*

This prototype clarified that the visual system is not separate from the sensing system. The particles are not decorative effects added after the fact. They emerge directly from the way the Kinect registers bodies through depth, distance, and partial spatial information. In that sense, the visual language of the work is shaped by the apparatus itself. Barad's account of phenomena is useful here, since she describes a phenomenon as the "entanglement/inseparability of 'object' and 'apparatus'" (Barad 2011, 142). In this prototype, bodily presence and visual form do not pre-exist that relation. They become legible through it.

The use of particles also changed how I understood visual presence in the installation. Representing the body through small points on a black background made presence feel unstable, emergent, and temporal. The body did not appear as a complete image, but as something continually coming into being, dispersing, and returning. This was important for the project because it aligned the visual language with my broader interest in trace, memory, and affective residue. What appeared on screen felt closer to a constellation, dust field, or atmospheric imprint than to a stable portrait.

The feedback loop made this even more significant. Rather than showing only the present moment, the system held onto movement as residue. A gesture remained visible for a time, interfered with what came next, and then slowly dissolved. This shifted the visual system from simple responsiveness toward durational relation.

This prototype therefore helped me understand memory as something enacted materially in the behaviour of the system. The past was not stored as a record. It remained active as a fading condition within the image and the sound. In this prototype, memory became visible as lingering particles and audible as reverberant sonic tails.

At the same time, the prototype revealed an important spatial limitation. Because the visuals were projected on a single wall, the interaction often became mirror-like and frontal. Participants could see themselves and their traces, but the relation remained oriented toward one surface. This suggests that the next stage should extend the feedback logic more fully into the room so that co-presence is not only seen on a wall but distributed across space. Even in this partial form, however, the prototype demonstrated that particles, feedback, and decay can function as a strong visual language for embodied memory.

The next iteration slowed decay in both the visual and sonic channels, so persistence is easier to perceive. Sound mappings were refined to introduce more variation, including mapping gesture speed or intensity to dynamics. Multi-body interaction needs to be extended, especially for sound, so collaborative agency is not limited to one tracked handset. I also tested changes that distribute engagement beyond the front wall, such as additional projection surfaces or spatial cues, so co-presence is staged as room-scale rather than frontal.

## From Theory to Practice: Co-Creation in Prototype 4

Prototype 4 made the project's theoretical framework materially legible. Rather than understanding co-creation as the joint production of a fixed artifact, this prototype showed it as the shared emergence of an evolving audiovisual state shaped through movement, response, and persistence across time. The participant did not simply trigger outputs. Their gestures entered a feedback relation with the system, where sound, particles, and visual traces altered the conditions of the next action. Co-creation, here, took form as a relational process rather than a moment of control.

This became especially clear through the combined sound and visual system. On the visual side, Kinect depth data was translated into a particle-based body image, so presence appeared as a field of points rather than as a stable photographic figure. Through feedback, those particles did not disappear immediately but remained as fading traces that gradually dissolved over time. On the sonic side, delay, reverb, and layered responses extended the duration of each interaction beyond the instant of contact. Together, these processes meant that each new gesture entered a field already shaped by what had just happened.

Pickering's account of the "dance of agency" is useful here because it frames practice as a temporal negotiation of resistance and accommodation rather than the execution of a fixed intention (Pickering 1995, 22). This logic became concrete in the prototype. As participants encountered the system, they adjusted their movement in response to sound intensity, particle behaviour, and fading traces. At the same time, the system's behaviour was continually shaped by thresholds, delay structures, feedback persistence, and the accumulated residue of previous gestures. Neither side fully determined the interaction. What emerged was a co-adjusted relation.

Rokeby's account of interactive systems also helps clarify what happened in this prototype. He argues that interactivity depends on the consequences of action being reflected in a perceivable way, so that participants can sense the relation between gesture and system response and modify their behaviour accordingly. In Prototype 4, this was not limited to immediate reaction. The system reflected action back not only as instant sound or image change, but as an atmosphere of persistence. This made feedback feel less like a direct command-response structure and more like a durational conversation unfolding through traces.

Barad's concept of intra-action further sharpens this point because it refuses the idea that human action and system behaviour exist as separate entities that then meet. Instead, relations produce the terms of the encounter. In Prototype 4, bodily gesture did not remain separate from system response. Movement, sound, particle formation, and fading residue emerged together within the same event. Presence became legible through the apparatus, and the apparatus became meaningful only through the presence it registered. Co-creation therefore did not describe two already-formed agents collaborating from the outside. It described a relational event in which gesture, response, and trace took shape together.

What this prototype demonstrated, then, was not a finished version of the final installation, but a working model of the project's central claim: that co-creation can be designed as a temporal, affective, and embodied process. Through sound, particles, and feedback persistence, Prototype 4 showed how relation can become the material of the work. Theory became legible not through abstraction, but through the behaviour of the system itself.

# Chapter VI.

# Final Installation and Exhibition Plan

## REB User Testing in a Simulated Exhibition Environment

Before the final exhibition, I conducted an REB-approved user test in a simulated exhibition environment whose dimensions closely matched the final Waterfront installation space. This testing phase combined the spatial logic of Prototype 5 with tactile materials, pressure sensing, light behaviour, and sound interaction developed in Prototypes 1 and 2. The goal was to observe how participants encountered and interpreted the installation, and to identify design issues to address before exhibition.

Rather than treating the session as a formal empirical study, I used it as a research-creation evaluation of the installation's relational behaviour. I examined how participants moved through the space, what attracted their attention first, whether sound and visuals felt aligned, whether pressure input and light response felt legible, and how the installation behaved when multiple people occupied the room. This phase also helped to test practical questions related to projection, visibility, and equipment choice for the final exhibition.

To prepare for the final exhibition at Waterfront Campus, I visited the site in advance, measured the assigned area, and created a layout based on its actual dimensions. This was necessary because the exhibition space was irregular and partially open, with an L-shaped footprint rather than a fully enclosed room. Since the site did not provide complete walls, I needed to test whether temporary fabric partitions could successfully define the space while also functioning as projection surfaces.

Using these measurements, I recreated the exhibition footprint for REB user testing at near full scale, approximately 123 inches by 157 inches. Drop cloth was used to form temporary walls and projection surfaces, allowing me to test whether the installation could create an immersive enclosure without relying on permanent gallery walls. Two short-throw projectors were mounted on extension poles, and the Kinect sensor was positioned within the setup to test projection coverage, body tracking, and participant movement under conditions like the final exhibition.

*Figure 30. Projection test during REB user testing, showing how the temporary fabric walls functioned as projection surfaces within the simulated exhibition layout.*

This user-testing environment combined elements from several earlier prototypes. The spatial and audiovisual components in this setup most closely resembled those developed in Prototype 5, while also incorporating the tactile interaction logic developed in Prototypes 1 and 2. At the center of the space, I introduced a central interactive object, which I began to think of as the “heart” of the system. Designed to be touched, held, or hugged, this object used pressure sensing to control heartbeat sound and LED light behaviour: when participants pressed the sensor, the heartbeat intensified, and the lights flickered and brightened. Including this object allowed me to observe how participants approached it physically and how its tactile logic related to the Kinect-based visual system.

The setup also served as a material and sensor test. Alongside the FSR-based interaction developed earlier, I explored whether an air-pressure sensor could produce a different tactile quality of response. This included testing a balloon-based interface instead of the earlier foam-and-fabric structure to compare softness, responsiveness, and bodily engagement. These trials helped determine what should be retained, refined, or removed before the final exhibition. More detailed notes on the pressure-object development and air-pressure sensor experiment are included in Appendix A.

## Data Collection

Participants were recruited through an invitation letter and completed a consent form before taking part in the REB user-testing session. I had also prepared a questionnaire and a semi-structured interview guide to support post-experience reflection. However, as the sessions unfolded, the testing environment became more conversational and socially dynamic than I had initially expected. Because of this, I shifted from relying on written responses to conducting short-recorded interviews with participants after they interacted with the installation. Participants had already been informed through the consent process that audio recording could be used.

This recorded interview format was useful to capture not only participants' spoken responses, but also hesitation, emphasis, and emotional tone in the moment of reflection. This was important for a project concerned with affect, co-presence, and lived experience, since these dimensions are not always fully expressed through written questionnaires alone.

The user testing involved both individual and group interactions. Some participants experienced the installation alone, while others entered in pairs or small groups. This made it possible to observe not only one-person engagement, but also how behaviour changed when other bodies were already present in the space. Across the session, I documented participants' comments about atmosphere, bodily movement, tactile interaction, audiovisual response, spatial layout, and the overall legibility of the system.[23]

## Interview Focus

The post-experience interviews were designed to gather participants' reflections on how they encountered and made sense of the installation. Rather than asking whether the system "worked" in a purely technical sense, the interviews focused on lived experience: what participants noticed first, how they interpreted the system's responsiveness, what drew their attention, and how the relationship between body and system changed over time.

Emphasis was placed on four areas. First, I asked about entry into the space: what participants noticed in their first moments, whether the room felt open, mysterious, or already active, and what elements initially guided their behaviour. Second, I asked about responsiveness and co-creation: when participants felt the system had "noticed" them, whether the experience felt more like control, collaboration, or negotiation, and how they understood what they and the system were producing together. Third, I asked about temporality and trace: whether the interaction felt immediate or delayed, whether the space felt fresh or shaped by previous encounters, and what participants felt they might have left behind for the next person. Finally, I asked about the installation as an integrated environment: whether sound,

[23] Full REB materials, including the invitation letter, consent form, interview guide, and anonymized interview notes, are included in Appendix B.

light, pressure, and projected visuals felt aligned, and what aspects of the installation felt confusing, disconnected, or especially effective.

These questions were intended to support the thesis's larger concerns with embodied interaction, co-creation, memory, duration, and the role of sensing systems in shaping how relation becomes perceptible.

### How Findings Informed Final Exhibition Decisions

The user testing clarified several strengths of the installation as well as a number of practical and conceptual issues that needed to be addressed before the final exhibition.

One of the clearest findings was that sound functioned as the strongest initial attractor. Across multiple interviews, participants described the space as mysterious, atmospheric, calming, or emotionally charged before they fully understood how to interact with it. The layered sound environment drew participants inward and established an anticipatory tone, often before they had identified the role of the object or the motion-based system. This confirmed the importance of treating sound not as a secondary layer, but as one of the main entry points into the installation.

A second major finding was that visual response was the clearest way participants recognized that the system had noticed them. Participants often described the moment of recognition as the point when they could clearly see their silhouette, body outline, clothing detail, or particle trace appear in the projected image. Some described this in terms of delay, fluidity, or conversation, suggesting that the visual system was experienced not simply as a mirror, but as a temporal transformation of bodily presence. This reinforced the decision to keep projection and body-responsive visuals central to the final installation.

*Figure 31. Multi-person interaction during REB user testing. Two participants engage the Kinect-based visual system as their movements generate a shared particle image, illustrating how bodily co-presence shaped the projected field during testing.*

The user testing also supported the project's interest in memory and duration. Several participants described the visuals as lingering, fluid, or gradually dispersing rather than disappearing immediately. This indicated that the feedback and particle systems were already communicating a sense of trace and temporal persistence. At the same time, one participant who entered the installation an hour after the previous interaction described the room as "untouched," suggesting that the installation's residual memory was perceptible only within a limited temporal window. This became an important clarification for the project: the system could hold traces, but not indefinitely. Memory, in this installation, functioned as decaying persistence rather than permanent accumulation.

The weakest element in the installation was the pressure-based hanging object. Although it often drew visual curiosity, many participants did not immediately understand that it was interactive. Some hesitated to touch it, while others touched it too gently because they were afraid of breaking it. Even when it was successfully activated, participants often experienced it as separate from the motion-based visual system. This was one of the most consistent findings across the interviews. In response, I decided that the core object needed to become softer, more inviting, and more clearly touchable, and that its interaction would need stronger integration with the projected visuals rather than operating through sound and floor light alone. (Figure 33,34)

*Figure 33. REB user testing of the hanging pressure-based object. The participant engages the tactile core object while the projected particle system remains active in the background, illustrating the spatial and perceptual relationship between touch-based and motion-based interaction.*

*Figure 34. Multi-person tactile interaction during REB user testing. Two participants hold and press the hanging pressure-based object together, illustrating how the object was tested as a shared interactive element within the larger audiovisual environment.*

Multi-person interaction produced another important insight (Figure 37.). Participants often enjoyed being in the space together, and in some cases the presence of other people encouraged entry, experimentation, and collaborative image-making. However, the current sensing arrangement and room scale also encouraged turn-taking rather than fully simultaneous co-creation. Participants adjusted their movement around one another, gave each other space, and sometimes mistook distance or occlusion for personal error. This suggested that the installation could support shared presence, but that the final exhibition would need a clearer decision about whether it was primarily designed for one body at a time or for multiple bodies interacting together.

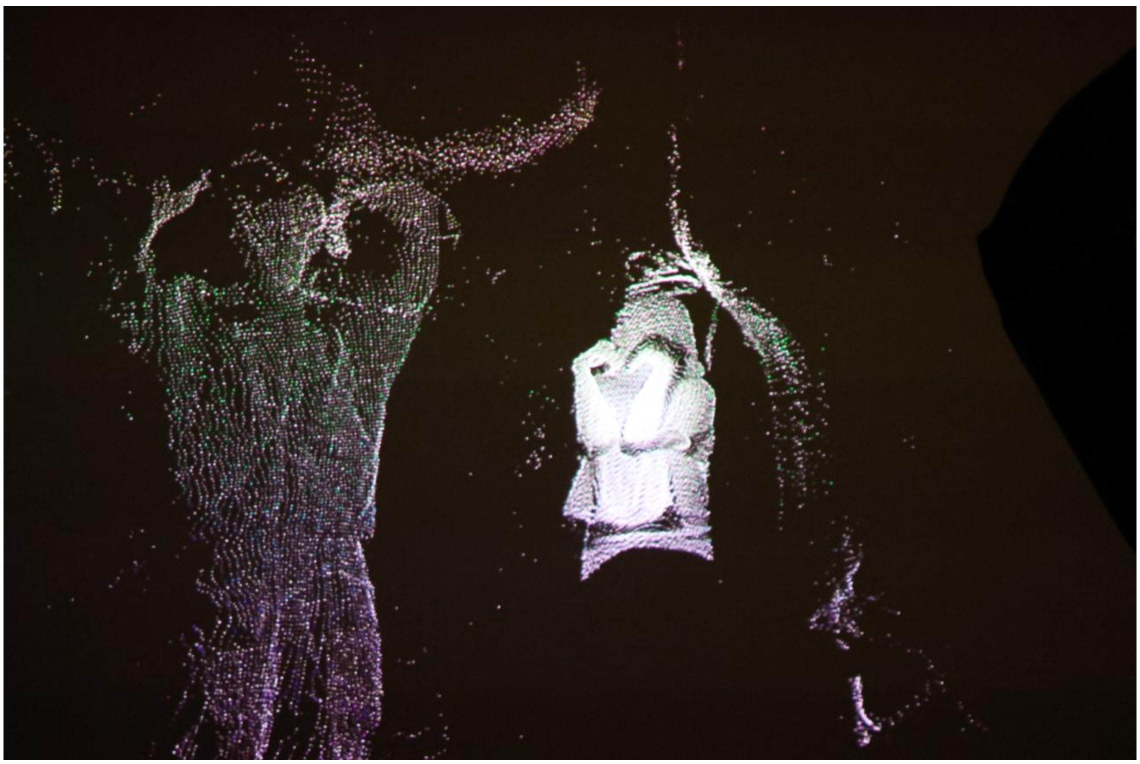

*Figure 32. Multi-person interaction produced another important insight. Participants often enjoyed being in the space together, and in some cases the presence of other people encouraged entry, experimentation, and collaborative image-making.*

The testing also confirmed the importance of spatial design. Participants responded differently to the wall and fabric projection surfaces (Figure 38.), describing them as carrying different moods and visual qualities. One participant, for example, described the fabric projection as fairy-tale-like and the wall projection as more futuristic. Another suggested that a more enclosed arrangement with additional projection surfaces would strengthen immersion and deepen the sense of entering another state. These responses supported the continued use of temporary fabric walls and projection surfaces, while also confirming that enclosure and material surface should be treated as active components of the installation rather than as neutral supports.

Overall, the user testing functioned as a critical bridge between prototyping and exhibition. It confirmed the installation's strongest qualities, including atmosphere, sound, visual responsiveness, and temporal trace, while also identifying key areas for revision. It showed the need for a more inviting and better integrated tactile object, stronger alignment between touch and visuals, and careful attention to how the final space would support one or multiple participants. These findings directly informed the final exhibition design.

*Figure 33. REB projection test showing the same visual system across two different surfaces. The fabric projection on the left produced a softer, more atmospheric image, while the wall projection on the right appeared sharper and more computer-generated, supporting participant observations that different surfaces created different emotional readings of the work.*

*Table 1Key REB findings and resulting exhibition decisions.*

| Key finding | Design response |
|---|---|
| Sound consistently drew participants into the space. | Keep sound as a primary atmospheric entry point. |
| Visual response was the clearest sign of recognition. | Maintain strong body-to-visual legibility. |
| Particle traces communicated delay and persistence. | Preserve feedback, decay, and trace-based visual behaviour. |
| System memory was perceptible only for a limited time. | Treat memory as temporary persistence rather than permanent storage. |
| The pressure object was not clearly inviting to touch. | Redesign it with softer, more graspable, and more legible materials. |
| The pressure object felt separate from the visual system. | Integrate touch more directly into projected visuals. |
| Multi-person interaction was playful but spatially constrained. | Refine the layout depending on whether the final work prioritizes one-body clarity or multi-user interaction for two at max. |
| Projection materials affected mood and immersion. | Use surface material intentionally as part of the installation design. |
| Participants wanted stronger enclosure. | Strengthen the spatial enclosure of the final exhibition. |
| Sonic atmosphere worked, but mapping was not always obvious. | Refine the sound system so interactive changes are more perceptible. |

Table note. Participants are anonymized as P1-P7. This table condenses the main observations from individual, and group post-experience interviews conducted during the REB user-testing session.

Based on these findings, I created the following table to clarify what should be retained and what needed to be revised before the final exhibition.

*Table 2. REB design directions for final exhibition.*

| Keep | Change |
| --- | --- |
| **Dark, atmospheric entry** drew participants into the space. | **Redesign pressure object**: softer, more inviting, and more clearly touchable. |
| **Sound as first attractor** often the first element participants noticed. | **Integrate touch with visuals:** touch, sound, light, and image operate as one system |
| Particle-based body image | **Improve touch affordance**: participants do not hesitate or fear breaking the object |
| **Feedback, decay, and trace** helped participants perceive lingering traces | Refine one-person vs two-person logic |
| Multi-person openness: MAXIMUM 2 | **Improve sound legibility:** more than half of participants wanted a more immersive surround condition. |
| Temporary fabric enclosure using drop cloths | **Strengthen surround immersion:** change the projector placement, and projector itself |

Taken together, these findings clarified that the final exhibition should preserve the installation's strongest qualities, atmosphere, sound, visual responsiveness, and temporal trace, while refining the tactile object, spatial clarity, and integration between sensory layers.

# Chapter VII.
# Conclusion and Future Directions

Taking this artistic journey felt like a constant gamble, something I questioned every step of the way, wondering if it will pay off, if I am worthy of taking it and capable of finishing it. The second-guessing devoured me at the start. Every idea I would later abandon felt like I was putting to rest the creativity I had used to come up with it. My eleventh, fifteenth, twentieth and thirtieth idea felt like it was being built on a never-ending burial site. I no longer saw ideas as current ideas, just as my eleventh, fifteenth, twentieth and thirtieth idea; always expecting I would have to come up with another one after. But I had deadlines, and I feared doing nothing more than failing, so my last idea, BECAME, my last idea.

I got to work on the foundation of *Synaptic Echoes*. I was burned out with nothing to show for it, and I spent weeks thinking I was working off desperation and not passion, and my results would be tainted because of that. What I missed then, that I understand now is that I was WORKING. I could not shape the clay in my mind, but I could in my hands. Piece by piece, I molded my project along. Hacking off pieces, overworking some areas, making mistakes, but making progress. It turned out that my hands are a lot smarter than I am.

When I had something to come to besides a studio full of talented colleagues and a blank Word document, I became hooked on adding more and more to this project. Some days were experimentation, others were research, some days were workshop, but every day *Synaptic Echoes,* and I grew.

I wanted to be a genius—or rather I was too scared what else would I be if I was not a genius? Now that I am here, now that I took the genius from my peers and my advisors, I went from asking for helping to giving help. Now that I stand in front of my year of work, I do not care about being anything, but the creator of *Synaptic Echoes* and I want to see it keep growing.

*Synaptic Echoes* explored how bodily presence and temporal interaction shape co-creative behaviour within a sensor-based technical system, while user testing clarified how participants perceived and entered that relation. Through research-creation and iterative prototyping, the project reframed interaction as relation rather than command. Participants did not encounter the installation as a simple trigger-response system. They often entered through sound and projection, then gradually learned the work through delayed traces, visual persistence, and shared image-making. The prototypes showed that attunement is not something added to technology afterward, but something shaped through pacing, feedback sensitivity, and responses that linger, soften, and return.

The project's central contribution is a practical and theoretical model of co-creation grounded in a three-layer memory architecture. The REB sessions showed that this model was most clearly felt through sound and projection, while the tactile object remained the least integrated element and needs further redesign. By treating memory as behaviour through immediate response, echo, and trace, *Synaptic Echoes* moves beyond reactive interactivity toward an environment that carries encounters forward. Agency did not sit fully with the participant or the system, but emerged between them, in the space where movement met response and each altered what came next.

Taken together, these findings suggest a response to the project's research questions. First, co-creative exchange did emerge between participants and the technical system, not as shared authorship in a literal sense, but as a relational process in which bodily activity and system behaviour continuously shaped one another. Second, memory, duration, and persistence proved central to that exchange: delayed traces, lingering visuals, and returning sonic shifts altered how participants moved, what they noticed, and how they understood the installation over the course of the encounter.

Taken together, these findings offer a response to the project's research questions. Co-creative exchange did emerge between participants and the technical system, not as equal authorship in a literal sense, but as an unfolding relation in which bodily activity and system behaviour continuously shaped one another. Memory, duration, and persistence proved central to that exchange. Delayed traces, lingering visuals, and returning sonic shifts changed how participants moved, what they noticed, and how they understood the installation over time. Co-creation, in this sense, happened not only in moments of immediate response, but in the intervals and returns that gave the encounter its depth.

The next development of the project follows directly from the prototype and REB findings. First, the spatial and sonic environment can be refined so that responsiveness is more immediately perceptible. Sound was one of the installation's strongest attractors, but its mapping was not always clear, and the enclosure and projection setup could better support immersion. Second, the work can more deliberately shape multi-person interaction. The REB sessions showed that co-presence was possible and often playful, but also spatially constrained, and the current setup sometimes supported shared image-making more clearly than fully simultaneous collaboration.

Future versions could allow interaction roles to shift through proximity and grouping or let memory traces accumulate differently when multiple bodies are present together. The work could also expand into longer-duration studies in which return visits alter the installation across days or weeks rather than within a single encounter. In that form, memory would not simply record what happened, but remain alive within the work, waiting to be stirred again. *Synaptic Echoes* suggests that an interactive installation can become a site of co-presence and co-creation by carrying traces forward, staying open to change, and slowly becoming with those who enter it. *

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# Appendices A. DFX Exhibition Documentation

## A.1. DFX Exhibition Installation Context

*Synaptic Echoes* was exhibited as part of the DFX exhibition at OCAD University's Waterfront Campus. The exhibition became an important extension of the thesis research because it allowed the project to move from prototype testing into a live spatial installation. While the written thesis discusses the conceptual and technical development of the work, the exhibition context revealed additional insights about spatial adaptation, audience interaction, and the symbolic role of the installation's central tactile object.

The installation was assigned to a corner area with only two permanent walls. Because the project relied heavily on projection and atmospheric immersion, this open spatial condition presented an immediate challenge. To create a darker and more enclosed environment, I built two temporary walls to partially contain the installation and reduce unwanted light interference. This spatial adaptation was necessary both technically and conceptually, as darkness and enclosure were important to the project's sensory atmosphere.

*Figure 34. Overall view of the installation being active at DFX show.*

## A.2. DFX Exhibition Installation Context

One of the most significant site-specific challenges was the presence of ceiling chandeliers that could not be removed. Rather than treating them only as an obstacle, I began to think of them as part of the installation's visual and spatial language. The chandeliers had a circular form with thin black branch-like lines, which suggested the possibility of integrating a branching structure into the environment.

In response, I added branches throughout the installation space to create a nest-like enclosure. These branches also evoked veins, nerves, or internal organic pathways, which contributed to the feeling of being inside a body or organ-like system. This intervention transformed an exhibition limitation into a conceptual opportunity. The resulting environment supported the project's broader exploration of embodiment, relation, and internal sensing.

*Figure 35. Overall view of the space before installing.*

*Figure 36. overall view of the space after installing, showing the enclosed corner space and projection environment.*

## A.3. The Centerpiece: The Heart

At the center of the installation, I created a soft sculptural object that became the symbolic core of the project. I referred to this object as **the heart**. It was constructed using soft felt cubes and spherical foam elements, resulting in a form that suggested an organic center without directly replicating the anatomical shape of a human heart. I wanted the object to remain symbolic rather than literal: a bodily core, a node of attention, and an emotional center within the system.

The heart was positioned on a raised base or altar-like platform in the middle of the space. This placement emphasized its importance and drew visitors toward it as a focal point. Conceptually, the heart represented the core of the installation's relational system. It functioned not only as a tactile interface, but also as a sculptural symbol of connection, vulnerability, and internal life.

Over the course of the exhibition, the heart became one of the most recognizable elements of *Synaptic Echoes*. It evolved into a visual and conceptual symbol of the project itself.

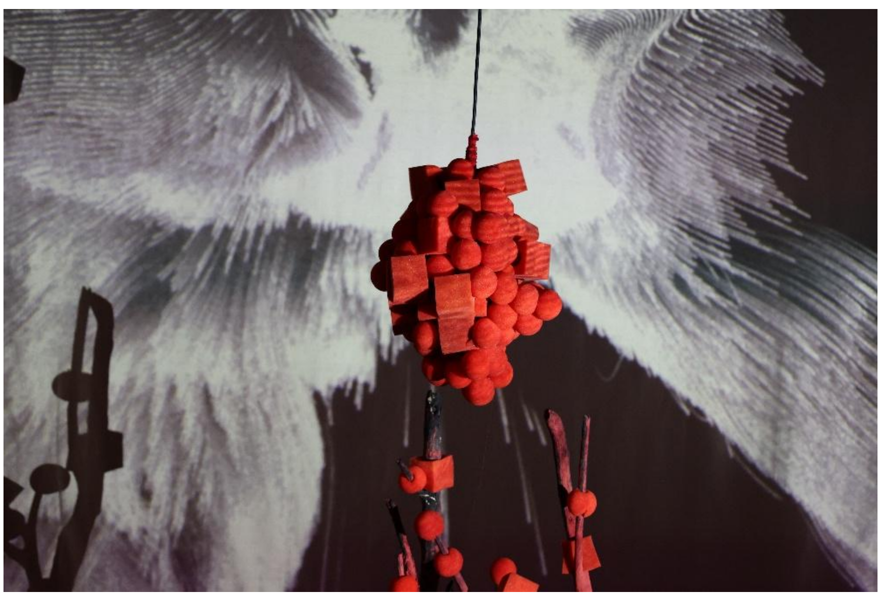

*Figure 37. The central tactile sculpture, referred to as "the heart," positioned at the center of the installation.*

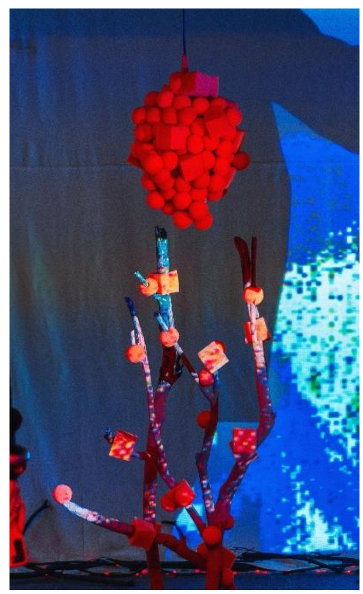

*Figure 38.Figure 37. The Altar underneath the heart to create a checkpoint for visitors.*

## A.4. Visitor Interaction with the Heart

Visitors were invited to engage physically with the heart by touching, pressing, or hugging it. These interactions triggered sound and visual changes within the installation. Hugging or pressing the heart activated heartbeat-like audio and contributed to changes in the projected visual environment. This interaction encouraged a more intimate and embodied mode of engagement, inviting participants to physically come close to the work rather than only observing it from a distance.

This tactile encounter reinforced one of the central aims of the thesis: to explore how human and technical systems can co-create an evolving sensory environment through bodily presence. The act of hugging the heart became especially meaningful, as it created a moment of closeness between participant and system. It suggested listening inward, as though bringing one's ear close to a body to sense what is happening inside it.

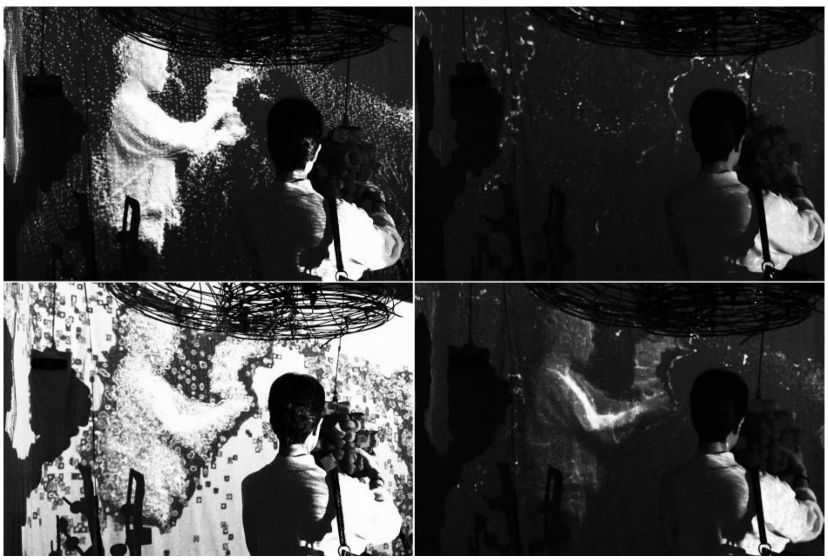

*Figure 39. A visitor interacting with "The heart", shifting through the visuals.*

*Figure 40. A visitor hugging with "The heart" and observing the changes in surroundings.*

## A.5. Audience Interaction and Co-Creation

The DFX exhibition also made visible the role of audience participation in shaping the work. Images of people moving through the space, observing the projections, and interacting with the heart demonstrate that the installation was not experienced as a static object, but as a relational environment. The exhibition context showed how bodily presence, movement, touch, and proximity activated and transformed the system over time.

Documenting audience interaction was important because it illustrated the project's central argument: that the work emerges through relation. People did not simply "use" the installation; they became part of its unfolding atmosphere. Their presence altered the audiovisual system, while the system, in turn, shaped their movements, pacing, and attention.

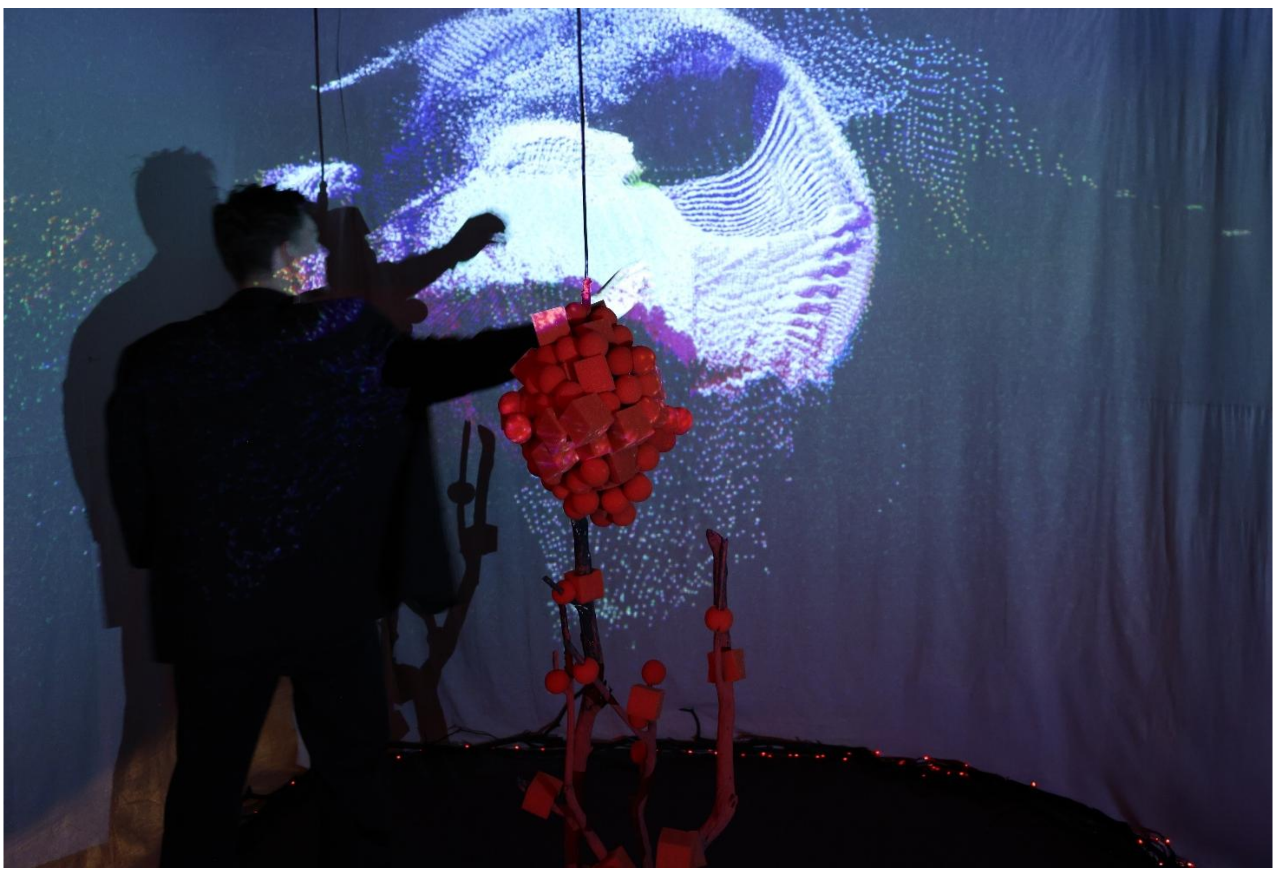

*Figure 41. A visitor moving in the space co-creating with the memory system.*

## A.6. Beyond Human-Centered Interaction

An unexpected but conceptually significant moment occurred when the depth sensor detected the heart itself as a form within the sensing field. This observation led me to think differently about the system's relational logic. Rather than being limited to human-only interaction, the installation appeared capable of responding to the presence of non-human forms within the environment as well.

This raised an important idea for the future development of the project: the system may be understood not only as a human-machine interface, but as a broader relational field in which objects, bodies, and sculptural forms can also participate. In this sense, the heart was not only an object to be touched by humans; it also became a sensed participant within the installation's logic. This expanded my thinking about the work beyond a strictly human-centered model of interaction.

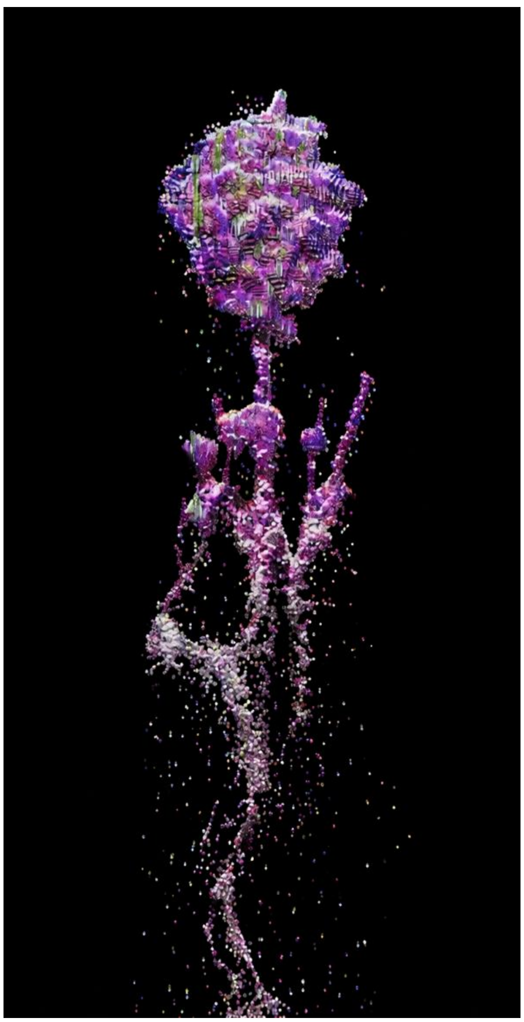

*Figure 43. Image captured from the Heart (centerpiece) through Kinect*

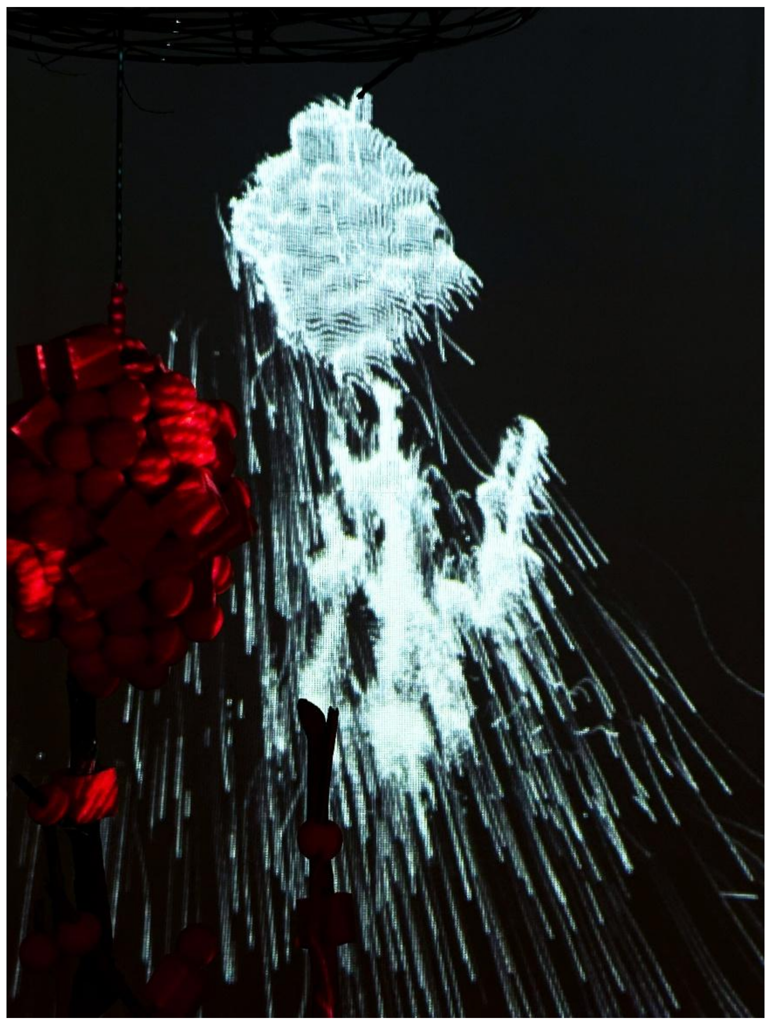

*Figure 42. The Heart (Centerpiece) in front of the system*

# Appendices B. Process Journal (Prototype Development Log)

*Table 3. Table of Prototype development*

| Date | Prototype it relates to | What you did | What to include as evidence |
|---|---|---|---|
| Jan 19, 2026 | Prototype 2 extension / Prototype 4 groundwork | FSR pressure signal → Arduino → TouchDesigner → LED brightness + heartbeat rate | Code listing (FSR smoothing, dead-zone, gamma), system flow diagram |
| Feb 2, 2026 | Prototype 4 | Integrated pressure heartbeat into the Kinect + Ableton system, unified audio inside Ableton | Code listings (pressure read, threshold), mapping notes, Ableton architecture notes |
| Feb 4, 2026 | Prototype 4 | Wiring and sensor stabilization for long cable runs + 12V light power separation | Pressure wiring diagram, 12V power/control diagram, notes on baseline subtraction and cable specs |
| Feb 11, 2026 | Prototype 5 | MPX5010DP air pressure interface test and calibration | Hardware table, code listing (raw read, threshold), observations |
| Feb 11, 2026 | Prototype 4 | Multi-sensor stabilization and long-distance wiring integration | Multi-sensor logic notes (baseline learn, noise gate), wiring diagrams |

## Sept 21. Prototype 1: Material affordances (Pressure interaction)

Description / intent

This session tested how tactile materials invite touching, squeezing, and handling.

**Guiding question:** How do materials shape relational entry points into the system?

Process / method (journal notes)

Built multiple soft enclosures: elastic balloons (with fillings), soft foam, felted wool, and a molded silicone ball.

Evaluated the first FSR prototype as a baseline (single sensor to pressure to sound).

Observations (notes)

Silicone: best tactile feel, but the molded ball could not be reopened and resealed.
Balloon + jellybeans: appealing texture but inconsistent triggering.
Soft foam: stable and dependable.
Wool: gentle and moderately dependable.

Participants approached foam and wool without hesitation but treated silicone cautiously.

Analysis / reflection

The object needs a familiar, non-threatening form so attention stays on the interaction rather than representation.

Action / next steps

Use foam and wool for early stable prototypes.
Revisit silicone using a split mold or cast-in inserts.
Move toward a multi-sensor array.

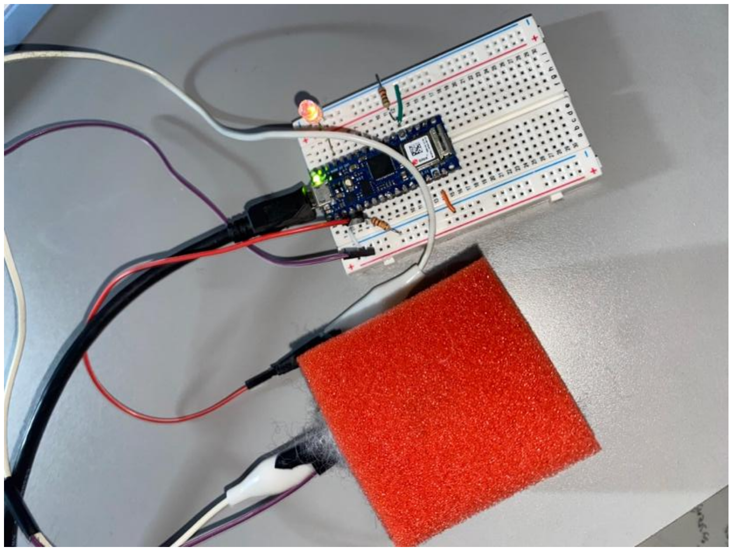

*Figure 44.early material pressure prototypes.*

## Sept 22. Prototype 2: Sound mapping setup (Audio scaffolding and TouchDesigner pipeline)

Description / intent

This session built the first audio feedback loop from pressure to sound.

**Guiding question:** How does bodily pressure become an expression?

Process / method (journal notes)

Pipeline

Arduino reads FSR values.

TouchDesigner receives values (Serial DAT → DAT to CHOP)

Pressure mapped to volume for legibility.

Observations (notes)

Participants immediately understood “more pressure = louder sound.”

Simple mappings helped participants learn interaction fast.

Action / next steps

Improve stability so idle noise does not trigger sound.

Begin testing how delay changes behaviour.

## Sept 23. Prototype 2: Stability and thresholds (dead-zone + smoothing)

Description / intent

This session reduced noise and accidental activations.

Process / method (journal notes)

Added a dead zone: treat values below a floor (example: 0.40) as 0.

Tightened smoothing to reduce jitter.

Observations (notes)

Interaction became more stable.

Dead-zone reduced accidental triggers.

Smoothing reduces the “twitchy” feeling.

Action / next steps

Add hysteresis (separate on/off thresholds).

Test multi-sensor overlaps and audio layering.

cpp  Copy code

```cpp
// FSR reading with dead-zone and smoothing (example structure)
const int fsrPin = A0;

const float deadZone = 0.40;   // normalized floor
const float alpha    = 0.10;   // smoothing strength

float smoothVal = 0.0;

void setup() {
  Serial.begin(115200);
}

void loop() {
  int raw = analogRead(fsrPin);         // 0..1023
  float v = raw / 1023.0f;              // normalize 0..1

  // dead-zone
  if (v < deadZone) v = 0.0;
  else v = (v - deadZone) / (1.0 - deadZone);

  // smoothing (EMA)
  smoothVal = alpha * v + (1.0 - alpha) * smoothVal;

  Serial.println(smoothVal, 4);
  delay(5);
}
```

*Figure 45. Code listing (Arduino, dead zone + smoothing)*

## Sept 28. Prototype 2: Time as material (hold to shift)

Description / intent

This session evaluated whether delayed feedback creates duration-based interaction.

Process / method (journal notes)

Hold-to-switch test:

Press starts Sound A

Holding for 10 seconds transitions to Sound B

Release stops and resets.

Observations (notes)

Participants understood press = A quickly.

The delayed shift invited lingering and curiosity.

Interaction became temporal, not only tactile.

Crossfade and micro-latency changed emotional tone.

Action / next steps

Create more instrumental or experimental sounds.

Extend time-based logic into “memory” behaviour later.

## Prototype 3 (add-on): Kinect v2 Depth + Infrared Sensing for Low-Light Co-Presence

To support visual co-presence in a projection-based, low-light environment, I transitioned from webcam-based MediaPipe tracking to Microsoft Kinect v2. Unlike RGB-only sensing, Kinect v2 combines a color camera with an infrared (IR) emitter + IR depth camera, allowing it to measure depth and produce an infrared image stream that remains readable even when visible lighting is reduced. This mattered for the installation because the projected atmosphere assumes darkness, and webcam tracking became unstable as light levels dropped. In this context, Kinect's depth and IR streams offered a more reliable way to register bodies as spatial presence rather than as purely optical images (Microsoft 2014).

Kinect's tracking reliability is also shaped by distance and field of view. The Kinect v2 body-tracking "physical limits" are **0.5 m to 4.5 m**, with an interaction "sweet spot" of **0.8 m to 3.5 m**. While depth values can extend beyond the body-tracking range (up to ~8 m), body detection does not function reliably in that extended distance. The depth camera's field of view is approximately **70° horizontal** by **60° vertical**, which sets practical constraints on how much of the room can be sensed from a single placement (Microsoft 2014).

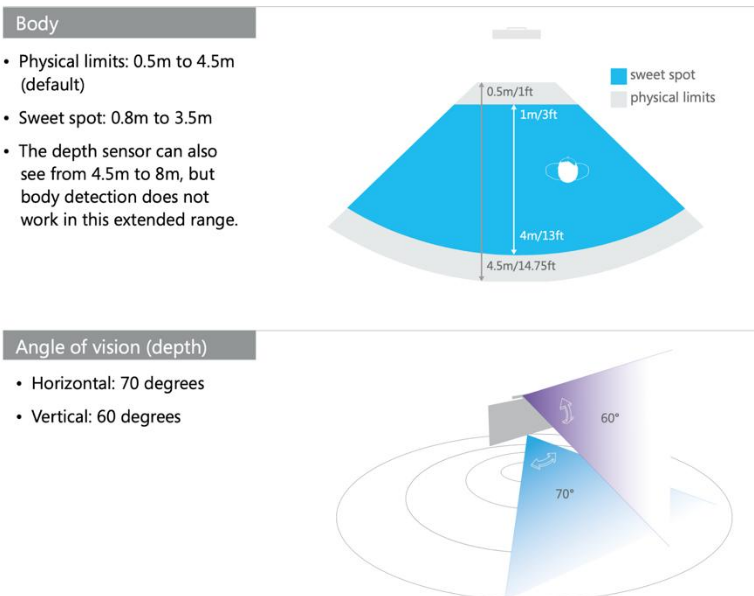


*Figure 47. Kinect v2 interaction range and depth field of view. Diagram showing body-tracking physical limits (0.5–4.5 m), interaction "sweet spot" (0.8–3.5 m), and the depth camera's approximate 70° (horizontal) × 60° (vertical) angle of view. Source: Microsoft, Kinect for Windows Human Interface Guidelines v2.0 (Microsoft 2014).*

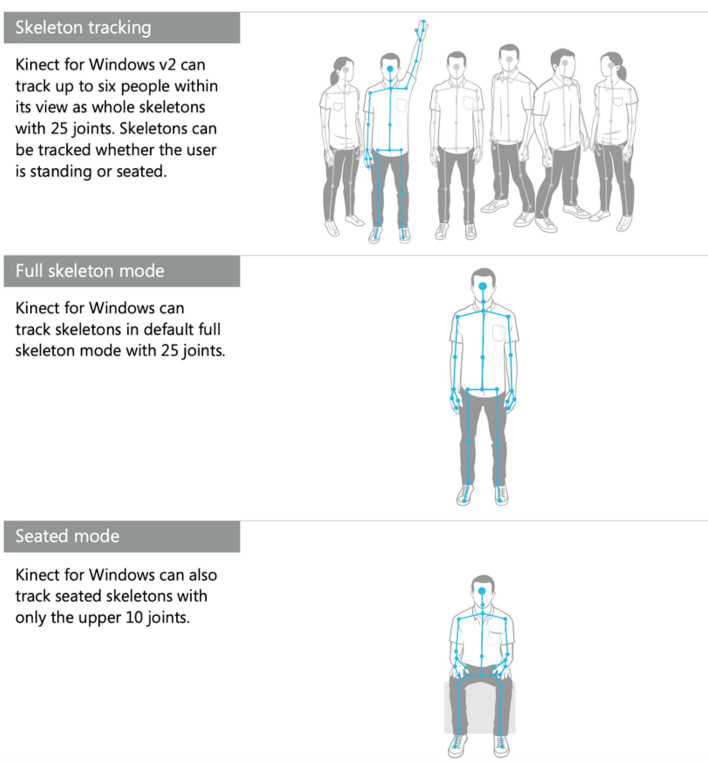


*Figure 46.Kinect v2 skeleton tracking modes. Diagram summarizing Kinect v2 body tracking capabilities, including tracking of up to six people, full-skeleton tracking with 25 joints, and seated mode tracking using upper-body joints.*

In low-light installation conditions, Kinect's IR depth camera is explicitly described as usable "in all lighting situations, even darkness," though performance is stronger in moderate light than in direct sunlight, and tracking can become less dependable under strong natural light conditions. Material qualities in the scene can also affect sensing: black clothing and highly reflective items may interfere with the infrared camera's ability to return stable data. In early tests, I treated these constraints as part of the design problem: the sensor's capabilities and limits actively shaped the spatial choreography the installation could invite (Microsoft 2014).

### How depth measurement works

Kinect v2's depth system is commonly described as a time-of-flight (ToF) approach: the device emits modulated infrared light and estimates distance by measuring how the returning signal shifts, producing a per-pixel depth map that can be used for segmentation, thresholding, and body tracking. In practice, this gives TouchDesigner a depth stream that is less dependent on visible illumination than webcam-based tracking, making it more suitable for dark, projection-driven environments (Wasenmüller and Stricker 2016).

## Mid Nov to Dec. Prototype 3 → Prototype 4: Kinect to Ableton control research

Description / intent

This session focused on moving beyond "visuals react to sound" toward "movement controls sound."

Process / method (journal notes)

Researched Kinect & TouchDesigner workflows.

Evaluated controlling Ableton via OSC output from TouchDesigner.

Focused on hands only:

Left hand X and Y

Right hand X and Y

Mapped those values to MIDI control inside Ableton.

Began dividing value ranges into note triggers (value bands mapped to notes).

Observations (notes)

Mapping approach required careful value thresholds to hit notes reliably.

The sensing system shaped what gestures were usable.

Action / next steps

Refine threshold bands and smoothing.

Decide whether the gesture should control notes, timbre, or mixing parameters.


*Figure 48. (data flow) Controlling Audio Volume and Speed with hand gesture*

TouchDesigner (Kinect tracking) → OSC out → Ableton (MIDI mapping) → sound output

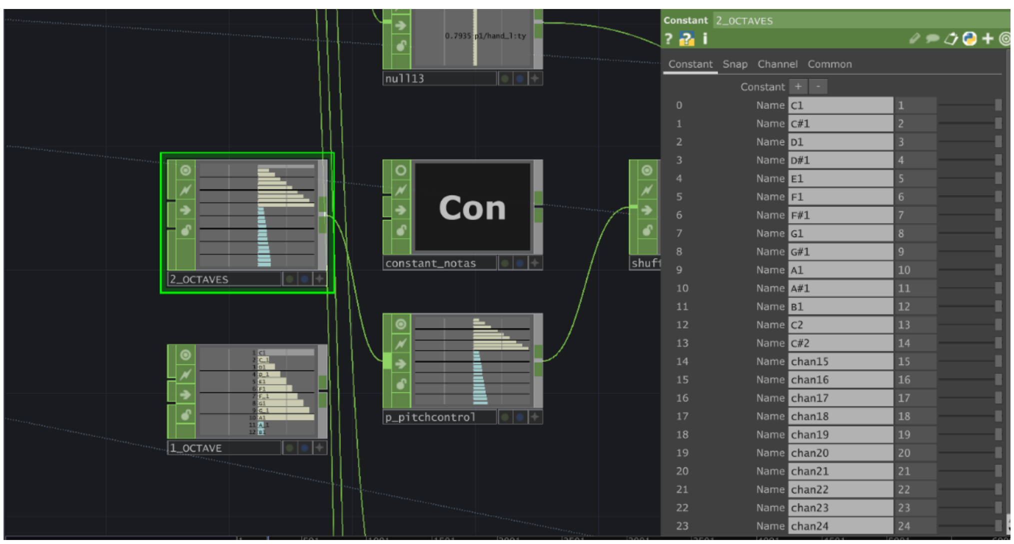


*Figure 49. I assigned each part of value to one note for example if the value is between 0.2 to 0.23 it will activate C# note*

## Jan 19. Prototype link: Pressure as "system organ" (pulse and light)

Description / intent

This session explored pressure as a pulse-like control system.

Prototype 2 extension / Prototype 4 groundwork (pressure as "system organ" using light + heartbeat)

Hardware configuration (notes)

Arduino Nano 33 IoT

DIY FSR in a voltage divider.

LED on PWM pin with resistor

Serial at 115200

Software and signal design

Smoothing (EMA)

Calibration range (minRaw, maxRaw)

Dead zone for baseline noise

Gamma shaping for expressive ramp.

Serial sends normalized value to TouchDesigner.

```
// Smoothing (reduces flicker/jitter)
float smoothed = 0.0f;
const float alpha = 0.12f;    // 0..1 (lower = smoother)
// Raw calibration (adjust after checking raw readings if needed)
int minRaw = 40;              // "no press" baseline raw ADC (example)
int maxRaw = 900;             // "firm press" raw ADC (example)

// Behavior tuning
const float deadZone = 0.12f;  // values below this are treated as 0 (your idle was ~0.09–0.11)
const float gammaVal = 2.2f;   // >1 makes low pressure much dimmer, more dramatic ramp
// Optional: keep a tiny idle glow instead of full OFF (0 = fully off)
const int minGlow = 1;         // try 0 for off, or 1–5 for barely-glowing
```

*Figure 50. Code Listing (Arduino: FSR smoothing + dead-zone + gamma + serial out)*

System behaviour (journal note)

Pressure → Arduino reads → Arduino sends value → TouchDesigner receives → LED brightness + heartbeat rate changes.

FSR + resistor voltage divider (one common layout):

3.3V → FSR → Analog pin

Analog pin → 10k resistor → GND

3.3V —— FSR ——●——— to Arduino Analog Pin (e.g. A0)

|

10kΩ

|

GND

*Figure 51. (FSR voltage divider wiring)*

## Conceptual structure (what the system *is doing*)

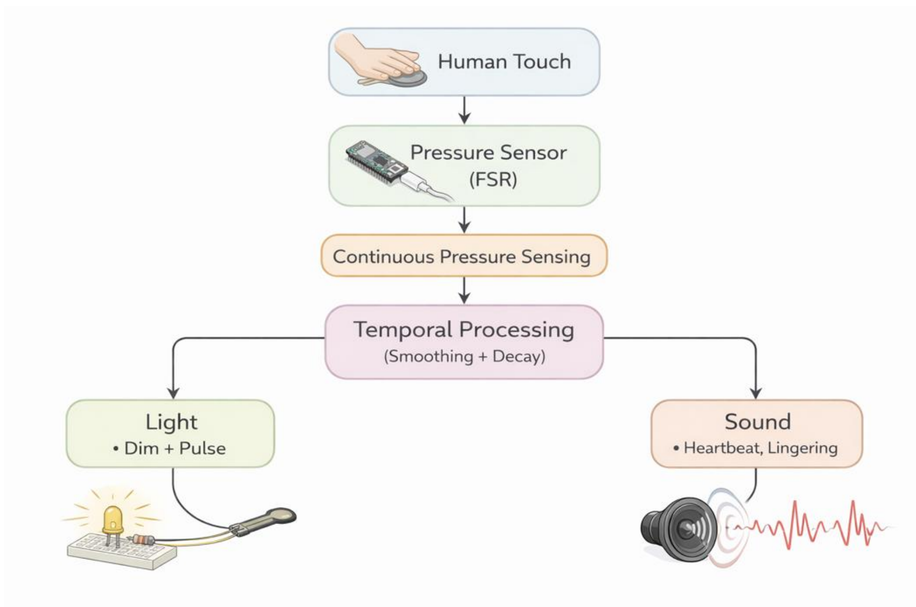


*Figure 52. Conceptual structure diagram (Human Touch → Pressure → Continuous Sensing → Temporal Processing → Light and Sound)*

Touch does not function as a trigger, but as a continuous modulation of system state. The pressure sensor translates embodied gesture into a signal that is temporally processed rather than instantaneously executed. Both light and sound emerge from this shared temporal memory, responding differently but remaining coupled through the same underlying state.

### Technical Diagram: What I Built Today

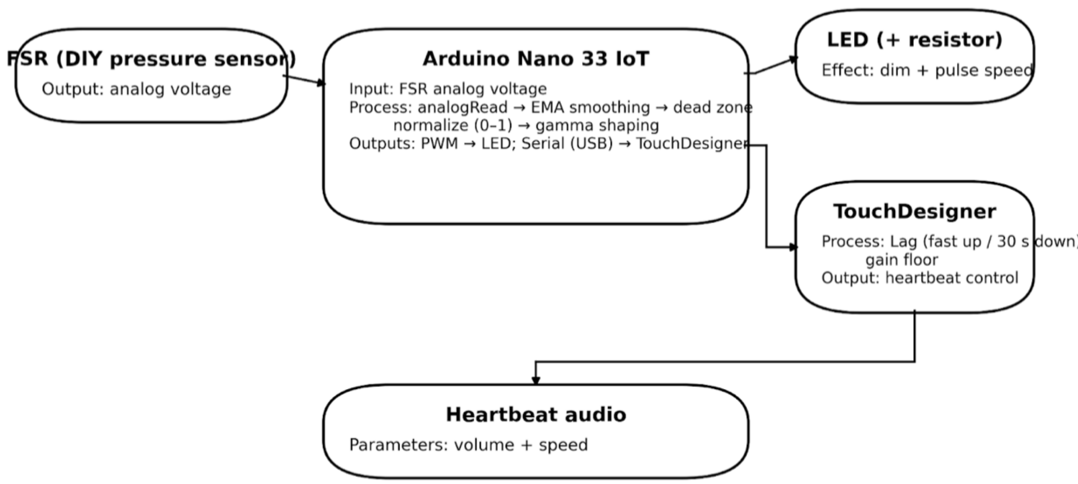


*Figure 53. Technical diagram: Hardware + software signal flow (FSR → Arduino processing blocks → PWM LED, Serial → TouchDesigner → heartbeat*

## Feb 11, 2026. Prototype 6: Air pressure interface (MPX5010DP)

Description / intent

This session focused on the integration and calibration of a differential air pressure sensor as a primary tactile input mechanism for the *Synaptic Echoes* installation. The objective was to evaluate whether air-based compression could produce a more embodied and organic interaction compared to surface-based force sensing.

The sensor used was the MPX5010DP, a differential air pressure sensor capable of detecting subtle changes in internal air pressure within a sealed chamber.

This experiment contributes to the broader research question:

In what ways can interactive multisensory installations evoke embodied emotional responses through non-verbal physical interaction?

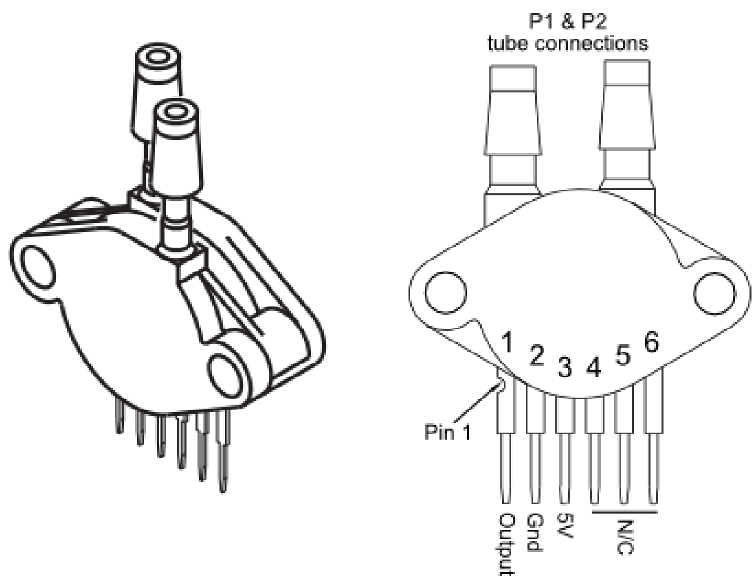


*Figure 54. differential air pressure sensor tube connections and pins.*

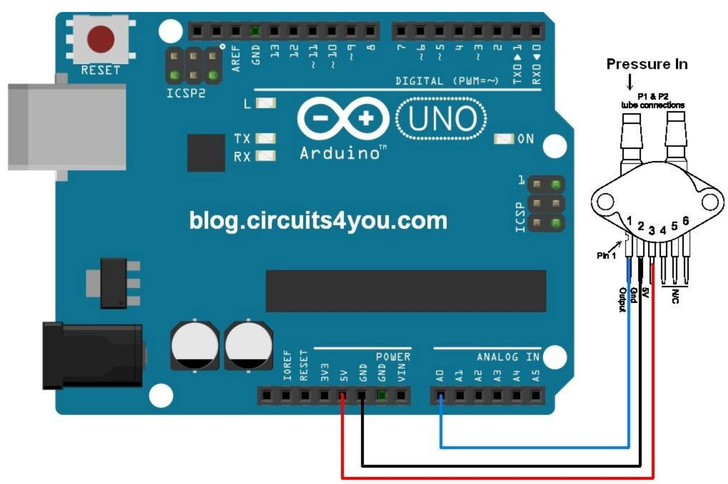


*Figure 55. differential air pressure sensor, wire framing*

2. Hardware Setup

Wiring

The sensor was wired as follows:

| MPX5010DP Pin | Arduino Connection |
|---|---|
| VCC | 3.3V |
| GND | GND |
| VOUT | A0 |

* Important discovery:
Initially the sensor was powered from **5V**, which caused harsh clipping and less stable readings. After switching to **3.3V**, the signal became significantly smoother and more stable, especially important when using a 3.3V logic board such as the Nano 33 IoT.

3. Sensor Behaviour Observed

Initial Readings (5V)

Rest: ~100–200

Full squeeze: 1023 (maxed out ADC)

This indicated saturation (clipping).

After Switching to 3.3V

Signal became smoother.

Range felt more controllable.

Better dynamic nuance in mid-pressure states

This improved the expressive quality of the pressure interaction.

4. Arduino Code Development

Version 1: Raw Output Test

I began with a simple raw-value reader:

```
const int pressurePin = A0;
```

```
void setup() {
 Serial.begin(115200);
}
void loop() {
 int pressureValue = analogRead(pressurePin);
 Serial.println(pressureValue);
 delay(20);
}
```

Purpose:

Verify wiring

Observe value range

Confirm serial communication

Version 2: Threshold Implementation (Dead Zone)

```
const int pin = A0;
void setup() {
 Serial.begin(115200);
}
void loop() {
 int raw = analogRead(pin);
 if (raw < 60) {
  raw = 0;
 }
 Serial.println(raw);
 delay(10);
}
```

Function:

Values below 60 are treated as inactivity (0)

Values above 60 pass through unchanged

No normalization occurs at the microcontroller level

Scaling and smoothing are managed in TouchDesigner.

This design choice preserves raw sensor data integrity while allowing expressive shaping in the media environment.

Observations

Physical Interaction

Compression produces gradual rather than abrupt changes.

The interaction feels more organismic than mechanical.

Air volume affects responsiveness; smaller chambers increase sensitivity.

Signal Behaviour:

3.3V supply improves stability.

Thresholding effectively eliminates micro-noise activation.

Full compression still produces strong upper-range values.

## Exhibition’s Floorplan map

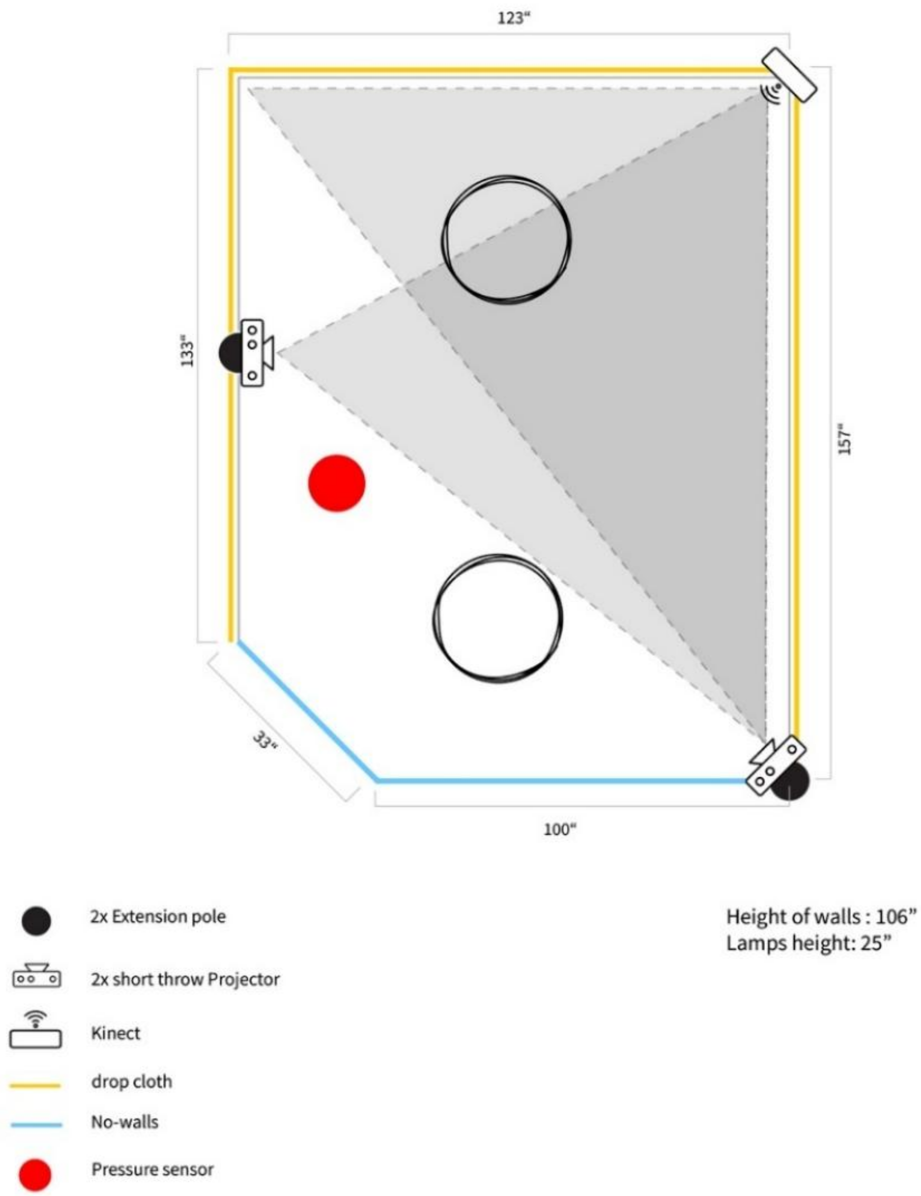


*Figure 56. Plan view of the simulated REB testing setup for Synaptic Echoes, reconstructed from measurements of the Waterfront exhibition space.*

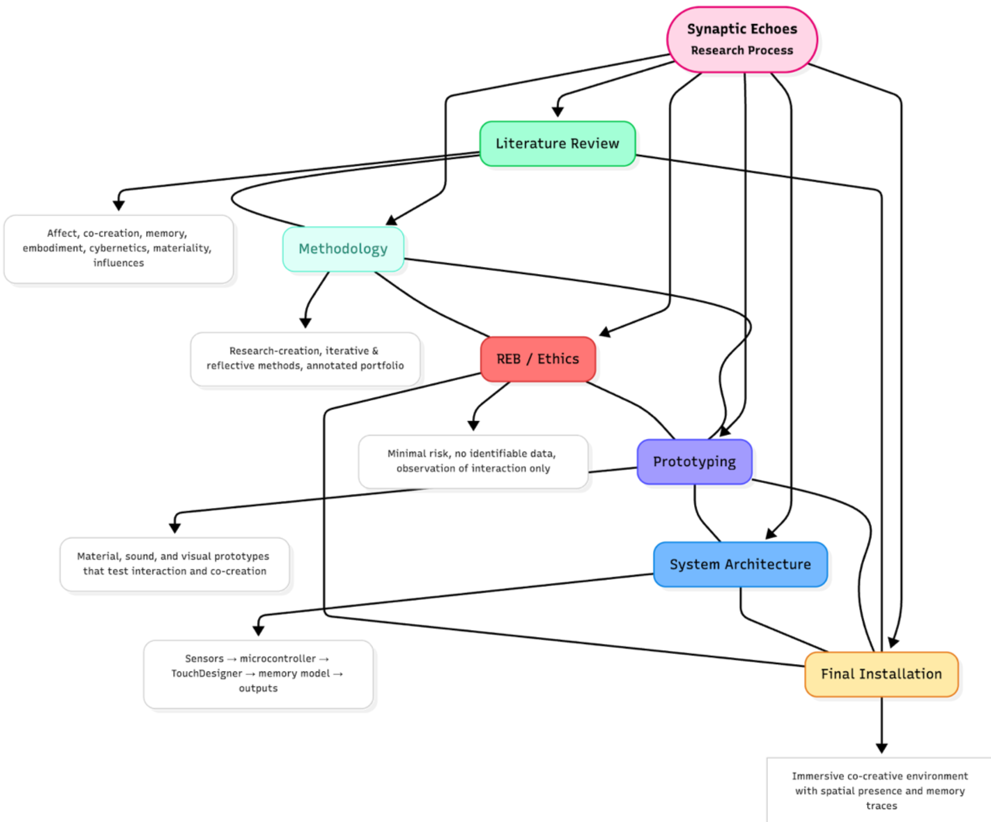


*Figure 57. Research process mind map*

By making these relations operative in the system's architecture, *Synaptic Echoes* treats technical implementation not as a neutral infrastructure but as a material articulation of its core ideas.

# Appendices C. Materials

## C.1. Prototype structure

### Prototype X: Title / Focus

#### Intro / Intent

What question was this prototype testing?
What were you trying to learn?

#### Process / Method

How did you build it?
What materials, sensors, and mappings did you use?
How does this connect to your methodology?

#### Observations (What Happened)

What did you notice in testing (technical, behavioural, affective)?
What did participants do?
What surprised you?

#### Reflection (What It Means)

What did you learn?
How does it connect to your conceptual framework (attunement, agency, memory, co-creation)?
Why does this matter for the next steps?

#### Next Steps

What changed because of this prototype?
What did it make you want to try next?

## C.2. Colloquium Summary

My colloquium presentation introduced my thesis project, which explores co-creation between humans and systems through a sculptural interactive installation composed of sensors, machine responses, and a memory-based behaviour model. The presentation articulated the central research questions, the conceptual roots of attunement and agency, and the role of memory, time, and traces within the system.

The audience responses strongly emphasized the significance of memory, shared space, relational aesthetics, and the blurring of human-machine distinctions. Several people connected the project to theoretical frameworks I had not yet explicitly considered, particularly Massumi's reading of Bergson in

*Parables for the Virtual*, and Karen Barad's "technosymbiosis" as productive directions for understanding spatial memory and distributed embodiment.

A major point of feedback was that while the sensory inputs were described in detail, the internal behavioural system, how memory operates, how traces persist, and how sensors influence one another requires clearer articulation and formalization. The audience also encouraged me to expand my conception of embodiment to recognize that the installation detects multiple bodies, not just individuals, making the system's memory inherently collective.

Overall, the colloquium clarified that my project is less about producing reactive behaviour and more about building a space that remembers, where human presence becomes an ongoing contribution to an evolving, shared, atmospheric aesthetic.

## C.3. Invitation for REB User-testing poster

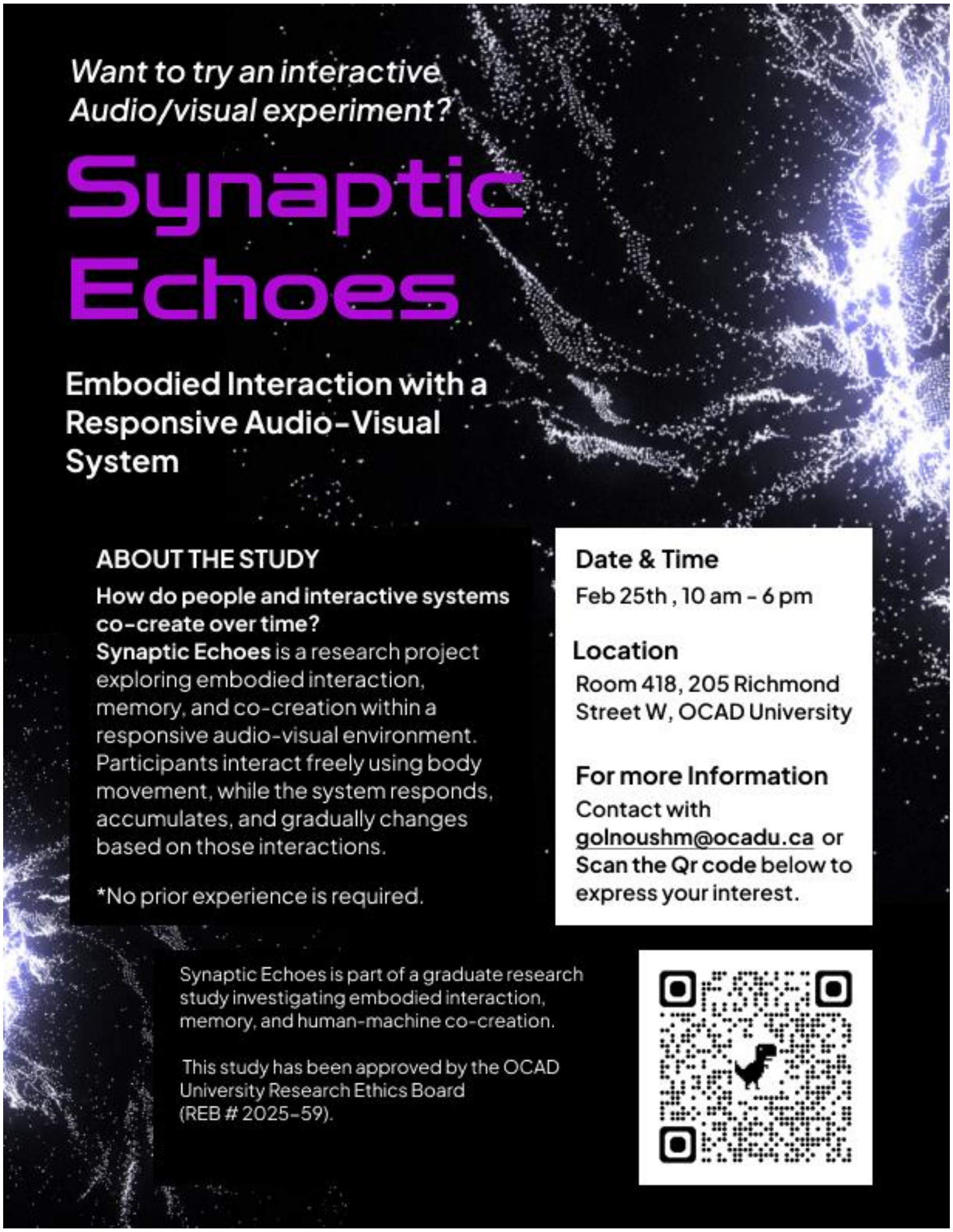


*Figure 58. Invitation poster for REB user testing*

## C.4. Invitation for REB user-testing post

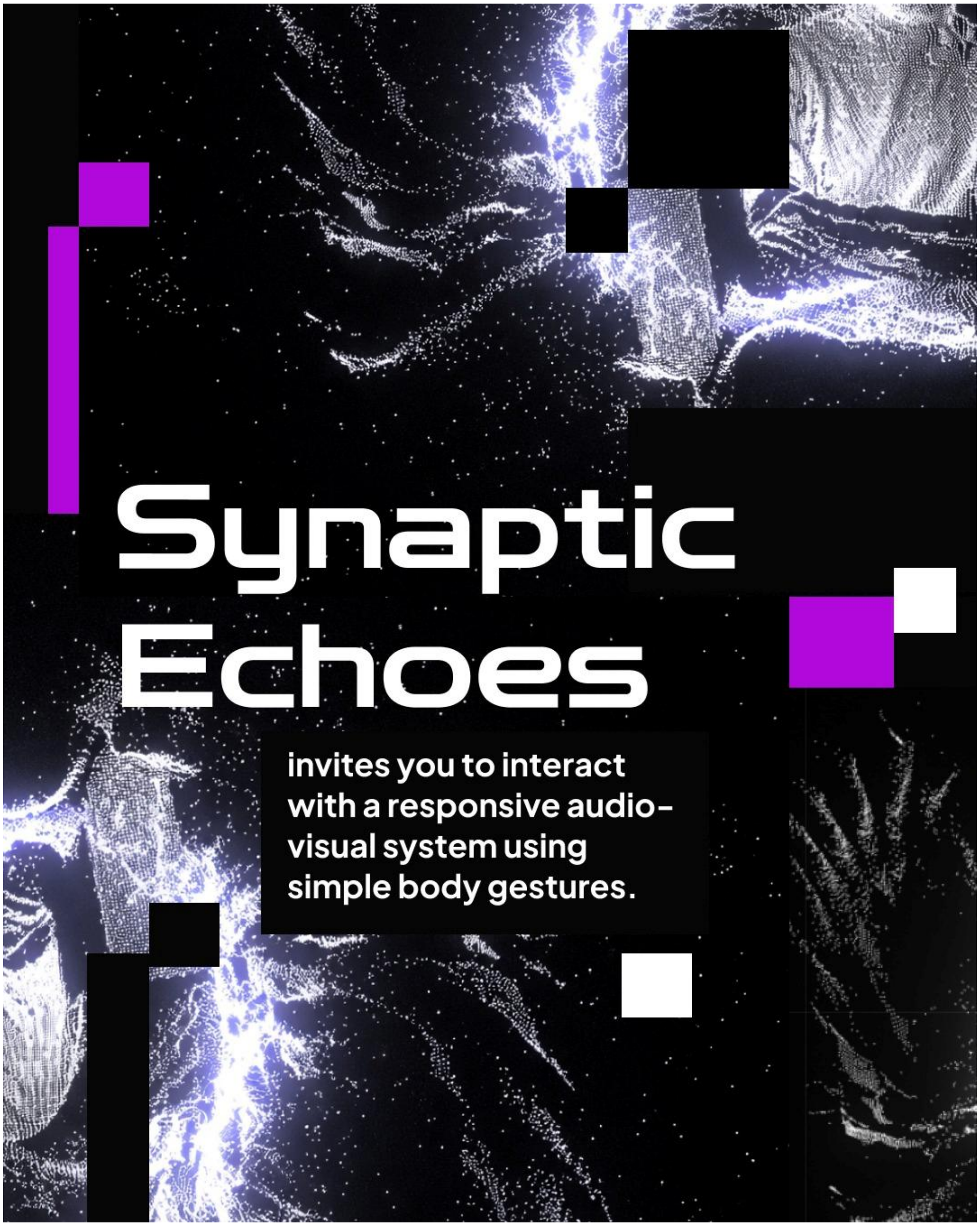


*Figure 59. Invitation post for REB user testing in Linked-in and Instagram.*

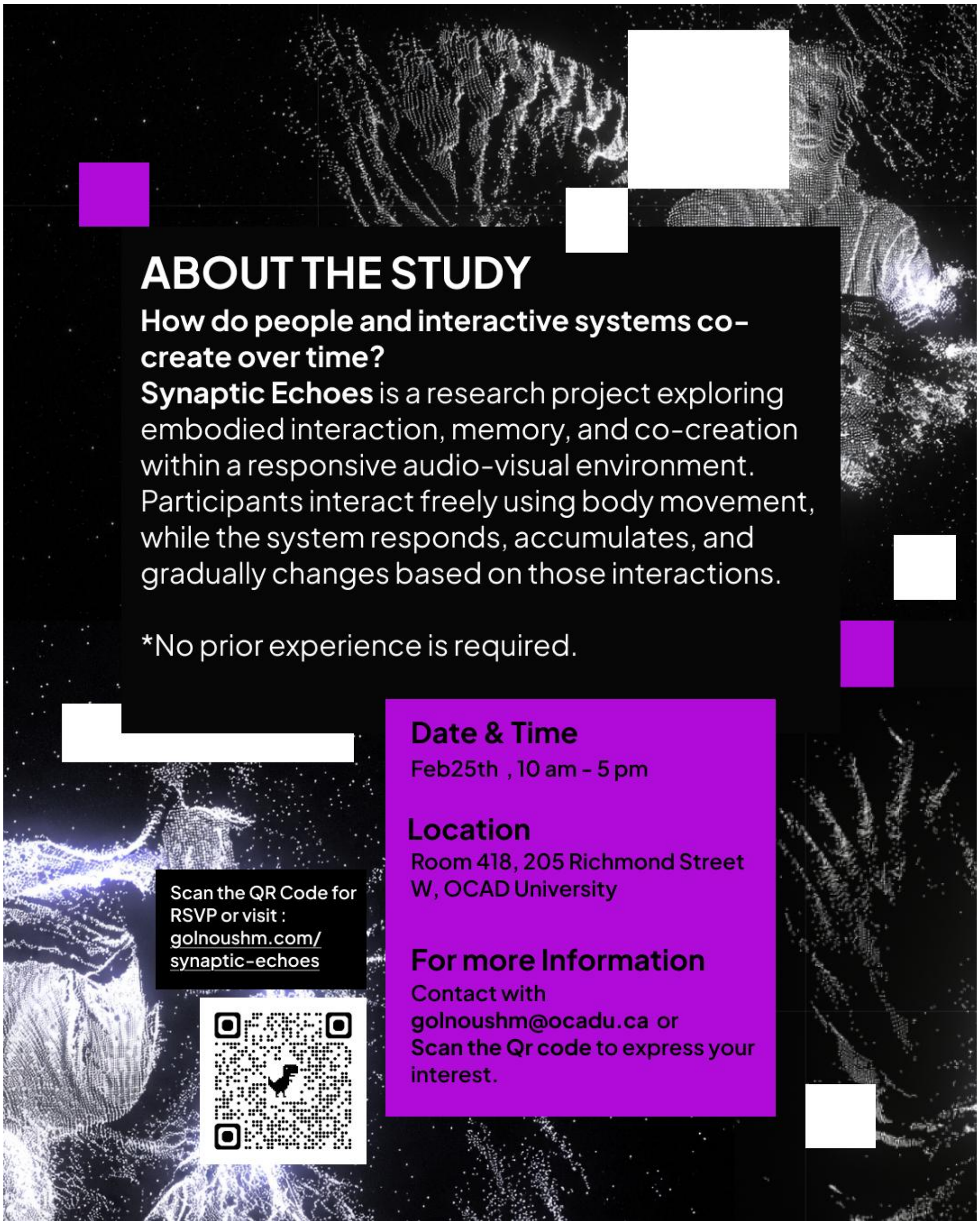


*Figure 60. Invitation post for REB user testing in Linked-in and Instagram*

## C.5. Consent Form (REB Approved)

Date: ___________________

**Project Title:** *Synaptic Echoes: Mapping Emotion Through a Posthuman Nervous System*

**Researcher:** Golnoush Mirsalari, MFA Candidate, Digital Futures, OCAD University

**Email:** golnoushm@ocadu.ca

**Supervisor (PA):** Simone Jones

Invitation

You are invited to take part in a study about how people can develop emotional attunement with responsive artworks over time. You will interact with a soft, sensor-based installation and share your impressions. Your feedback will help us understand how non-verbal interaction (touch, sound, presence) can shape a shared emotional experience with a machine.

What's Involved

If you agree to participate, you will:

Interact with the installation (e.g., touch/hold the soft surface, speak near it, remain nearby).

(Optional) Wear a simple **pulse sensor** (ear-clip or fingertip) during interaction. This is **not medical** and is used only to drive real-time audiovisual responses.

Complete a short questionnaire (3–5 slider questions) and a brief interview (about 5–7 minutes) about your experience.

**Time:** 20**–30 minutes** total (including consent and debrief).

**Location:** Studio 610, Floor 6, 205 Richmond St W

Potential Benefits and Risks

Benefits

Try a new multisensory artwork and reflect on how it "meets" you over time.

Contribute to research on embodied, co-creative human–machine interaction.

**Risks (minimal) and how we address them.**

**Physical:** mild eye fatigue or audio discomfort; tripping in a dim room; light touch on soft surfaces.

Mitigation: adjustable audio levels, no strobe lighting, clear floor paths, soft edges, ability to pause/stop at any time.

**Psychological:** some participants may feel tension, empathy, or other emotions.

Mitigation: You may pause or stop at any time and skip any activity or question without penalty.

**Biosensing (optional):** minor skin sensitivity from the ear/finger clip. You may **decline** this without affecting participation.

Confidentiality & Data Handling

During your session, we may record **interaction logs** (e.g., timestamps, dwell time, sensor events).

If you consent, we will **audio-record** the short interview. Video of the interaction is optional and used only to analyze general movement (not identity).

**Biosignals:** pulse input is processed **live** to drive the artwork; **raw biosignal data are not stored**. If you opt in, we may save **derived, non-identifiable metrics** (e.g., average beats-per-minute over the session).

No names will appear in any report. Data will be stored on **OCAD U-approved cloud storage** (restricted access) and kept until **December 31, 2026**, then securely deleted.

You may withdraw your data **before anonymization/pooling**:

**Round 1 (Fall 2025):** until **November 15, 2025**

**Round 2 (Winter 2026):** until **March 15, 2026**

After these dates, data will be anonymized and cannot be withdrawn.

Voluntary Participation

Participation is voluntary. You may decline any question or activity and may stop at any time without penalty or loss of benefits to which you are entitled.

Publication of Results & Feedback

Results may appear in exhibitions, the MFA thesis, conference talks, and scholarly publications. Quotes from interviews will be anonymized and used only with your permission. If you would like a summary of results when available, please indicate below.

Contact & Ethics

Questions about the study: contact the researcher or supervisor (emails above).

This study has been reviewed and received ethics clearance from the **OCAD University Research Ethics Board**. For concerns, contact **research@ocadu.ca**.

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Consent

Please initial each line and check optional items as you wish.

**Core participation**

______ I have read and understand the information above and agree to participate.

**Optional components**

______ I consent to **audio recording** of the interview.

______ I consent to **video recording** of my interaction with the installation.

______ I consent to the use of an **optional pulse sensor** (ear/finger clip).

______ I consent to the use of **anonymous quotes** from my interview in publications/exhibitions.

**Results**

[] Yes, please send me a summary of results when available.

Email for results (optional): ________________________________________

**Right to withdraw**

I understand I may withdraw at any time during the session. I may request deletion of my identifiable data up to **Nov 15, 2025** (Round 1) or **Mar 15, 2026** (Round 2).

**Signature**

Participant Name (print): _____________________________________________

Signature: ____________________________________________________________

Date (YYYY-MM-DD): __________________________________________________

Researcher Name (print): ______________________________________________

Signature: ____________________________________________________________

Date (YYYY-MM-DD): __________________________________________________

*Please keep a copy of this form for your records.*

## C.6. Interview Question Sheet

**Interview**
Synaptic Echoes: Multi-sensory Installation

OCAD UNIVERSITY

**Researcher:** Golnoush Mirsalari,
MFA Candidate, Digital Futures, OCAD University
**Email:** golnoushm@ocadu.ca

Thank you for joining Synaptic Echoes. I'm interested in your lived experience of the installation. There are no right or wrong answers. Please share as much or as little as you like. You may pause, skip any question, or stop at any time.

**I'm interested in what you noticed and how you made sense of it. Feel free to describe specific moments.**

1. Talk me through your first 30 seconds in the space. What did you notice first, and what did you notice next.
- What pulled your attention most ( sound, light, the object, or your own body)?

2. Describe one moment when you felt the system 'noticed' you. What were you doing right before, and what happened after?
- What do you think the system was responding to?

3. How did it feel to influence the system? Did it feel more like steering, collaborating, or being guided?
- If you had to split it 50/50: how much was 'you directing it' vs 'it directing you'?

*Figure 61. Data Collection Instruments – Interview Guide Page 1*

**Interview**
Synaptic Echoes: Multi-sensory Installation

**Researcher:** Golnoush Mirsalari,
MFA Candidate, Digital Futures, OCAD University
**Email:** golnoushm@ocadu.ca

4. Compare the beginning, middle, and end of your time inside. What shifted in the system, in you, or in the relationship between you?
   - Was there a moment you settled into a rhythm? What did that rhythm look like?

5. If you had to describe what you and the system created together, what would you say it was?

6. Did the space feel 'fresh' when you arrived, or already shaped by something? What do you think you left behind for the next person?

7. Did the presence of other people change what you did or how the space behaved?

8. What words describe how the installation met you emotionally (or physically)?

9. anything to add / anything to remove from recording

*Figure 62. Data Collection Instruments - Interview Guide Page 2*

## C.7. REB Interview Entry

### Interview 1: P1–P2

P1 and P2 described the installation as intriguing but initially unclear at entry. Darkness, sound, and the suspended star object created curiosity, but also hesitation, especially because touch was not immediately legible as permitted. Responsiveness became clearest when participants noticed brighter floor light, louder pulse-like sound, and particle movement reacting to their bodies. A key observation from this interview was that the pressure object and the Kinect-based visual system were experienced as separate layers rather than as one unified interaction. At the same time, the shared interaction space supported play, coordination, and collaborative image-making, even if the system did not yet feel fully emergent to them.

### Interview 2: P3

P3 encountered the installation primarily as an atmospheric and anticipatory environment. Sound, darkness, and low light created what they described as a "mysterious and spiritual journey," giving the sense that something was about to happen before the interaction was fully understood. The participant recognized responsiveness most clearly when squeezing the hanging object caused it to light up, but they also hesitated at first because they were unsure how to touch it and did not want to break it. This interview showed that the tactile-light interaction produced excitement and affective engagement, while also revealing a design gap: the participant expected that this moment would lead to a stronger visual transformation.

### Interview 3: P4–P6

The group interview with P4, P5, and P6 showed that interaction unfolded through orientation, testing, and gradual negotiation with the system. Participants used the projected surfaces, floor markings, and each other's behaviour as cues for how to enter and move within the space. They most clearly felt noticed when their full bodies were visibly registered, or when leaving and re-entering the sensing field caused them to appear and disappear. They did not describe the installation as a simple mirror; instead, they referred to it as a conversation, a relationship, or a collaborative medium. At the same time, the current sensing setup and room scale appeared to encourage turn-taking more than truly simultaneous co-creation, while the tactile object remained the least integrated and least inviting element.

### Interview 4: P7

P7 responded most strongly to the installation's emotional and atmospheric qualities. Music and projection drew their attention first, and they described the two projection surfaces as producing different moods: the fabric felt more dreamlike, while the wall felt more futuristic. The participant felt most recognized when the projected image captured detailed features of their clothing and outline, and they described the interaction as beginning through their own movement but continuing through the system's autonomous dispersal of particles. Emotionally, the work was experienced as soothing, reflective, and "weirdly emotional," evoking associations with stars, memory, death, and future or alternate selves.

Because this participant entered an hour after the previous interaction, their sense that the space felt "untouched" also suggests that the system's traces faded over time and were not indefinitely perceptible.

## C.8. REB User-Testing Materials and Interview Notes

This appendix section includes the materials and interview notes associated with the REB-approved user testing conducted for *Synaptic Echoes*. The testing was designed to evaluate how participants encountered and interpreted the installation in a simulated exhibition environment that closely matched the spatial conditions of the final Waterfront exhibition site. The materials gathered here include the invitation letter, consent form, interview guide, structured summaries of anonymized participant interviews, and tables identifying recurring themes across participant responses. These materials are included to document how participant feedback informed the final exhibition design, particularly in relation to atmosphere, spatial layout, audiovisual responsiveness, tactile interaction, and the role of temporal trace within the installation.

*Table 4. Participants Interaction summary across REB user-testing*

| Interview | Participants | Entry experience | Clearest sign of response | How the interaction was described | Main strengths observed | Key issues identified | Key suggestions |
|---|---|---|---|---|---|---|---|
| Interview 1 | P1 and P2 | Dark, mysterious, hesitant; unsure whether touch was allowed | Brighter floor light, louder heartbeat, moving particles | Responsive; partly collaborative; "visual delay" | Strong atmosphere, sound as attractor, visual trace, multi-person image composition | Pressure object unclear at first and disconnected from visuals | Integrate object with visuals; make it handheld, wireless, or more graspable |
| Interview 2 | P3 | Mysterious, spiritual, anticipatory | Squeezing the object caused light change and excitement | Journey, discovery, emotional unfolding | Strong sound atmosphere: tactile-light moment produced excitement | Participant unsure how to use object; expected something more to happen visually afterward | Make tactile affordance clearer; strengthen visual consequence of touch |
| Interview 3 | P4, P5 and P6 | Oriented through screens, floor markings, and other people | Full-body registration, dematerialization, reappearance | Conversation, relationship, collaborative medium, give-and-take | Rich multi-person experimentation, strong visual engagement, sound felt temporally alive | Setup encouraged turn-taking; sound mapping not always obvious; | Improve multi-user logic; soften and clarify object; develop sound |

| Interview | Participants | Entry experience | Clearest sign of response | How the interaction was described | Main strengths observed | Key issues identified | Key suggestions |
|---|---|---|---|---|---|---|---|
| | | | | | | tactile object unclears | variation over time |
| Interview 4 | P7 | Music and wall projection were first attractors; calm and reflective | Seeing detailed body outline and clothing features | Mostly participant-led, with the system carrying traces forward | Strong emotional response: projection materials produced different moods | Entered after long gap, so prior traces had faded; tactile object was not central to experience | Increase enclosure; use surrounding projections; treat surface differences intentionally |

**Table note.** Participants are anonymized as P1-P7(participant 1-participant 7). This table condenses the main observations from individual, and group post-experience interviews conducted during the REB user-testing session.

*Table 5, Recurring themes across participants interviews*

| Theme | Recurring pattern across interviews | Participant evidence / notes |
|---|---|---|
| First attractor | Sound was the strongest initial attractor in most interviews. | Participants often noticed the sound before understanding the interaction logic of the installation. |
| Entry condition | Participants entered with curiosity, hesitation, or a need for orientation. | Several participants were unsure whether touch was allowed or where they were supposed to stand. |
| Atmosphere | The installation was described as mysterious, calming, spiritual, reflective, or emotionally charged. | Darkness, low light, and layered sound created anticipation and affect before interaction was fully understood. |
| Clearest sign of response | Visual projection was the clearest sign that the system had noticed the participant. | Participants most often recognized responsiveness when they saw their silhouette, outline, particle trace, or clothing detail appear. |
| Temporal behaviour | Participants noticed delay, persistence, fading, and gradual dispersal in the visuals. | Several participants described the projected response as fluid, delayed, or lingering rather than immediate and fixed. |
| Memory / trace | Trace was perceptible in short-term interaction, but not indefinitely. | One participant who entered after a long gap described the room as “untouched,” suggesting that prior traces had faded beyond perception. |

| Theme | Recurring pattern across interviews | Participant evidence / notes |
|---|---|---|
| Tactile object legibility | The hanging pressure object was the least legible element. | It often attracted visual curiosity, but participants were unsure whether it was interactive or hesitated to touch it. |
| Touch affordance | The object did not clearly invite touch. | Some participants touched it very gently because they were afraid of breaking it; others suggested softer, more graspable materials. |
| System integration | Participants wanted stronger alignment between touch, sound, light, and visuals. | The tactile object was frequently experienced as separate from the motion-based visual system. |
| Co-creation / control | Interaction was often described as responsive, conversational, or collaborative rather than fully controlled. | Participants referred to the system as a conversation, relationship, give-and-take, or medium that transformed their input. |
| Multi-person interaction | Shared participation increased play, observation, and experimentation. | Participants often used each other as cues for how to enter or interact. |
| Spatial limitation | The current setup often encouraged turn-taking rather than full simultaneity. | Participants adjusted position, avoided overlap, or interpreted tracking limits as personal error. |
| Projection material | Different projection surfaces produced different emotional and aesthetic readings. | Fabric was described as softer or fairy-tale-like, while wall projection felt more futuristic or direct. |
| Enclosure / immersion | Participants wanted a more enclosed environment. | Some suggested that more surrounding walls or projections would strengthen the sense of immersion. |
| Sound legibility | Sound worked strongly as atmosphere, but its exact mapping was not always obvious. | Participants often felt the sonic environment clearly, but not always how their movement was shaping it. |

**Table note.** This table summarizes the most consistent themes identified across the anonymized REB interviews. It is intended as an interpretive guide to the interview material rather than a quantitative coding matrix.

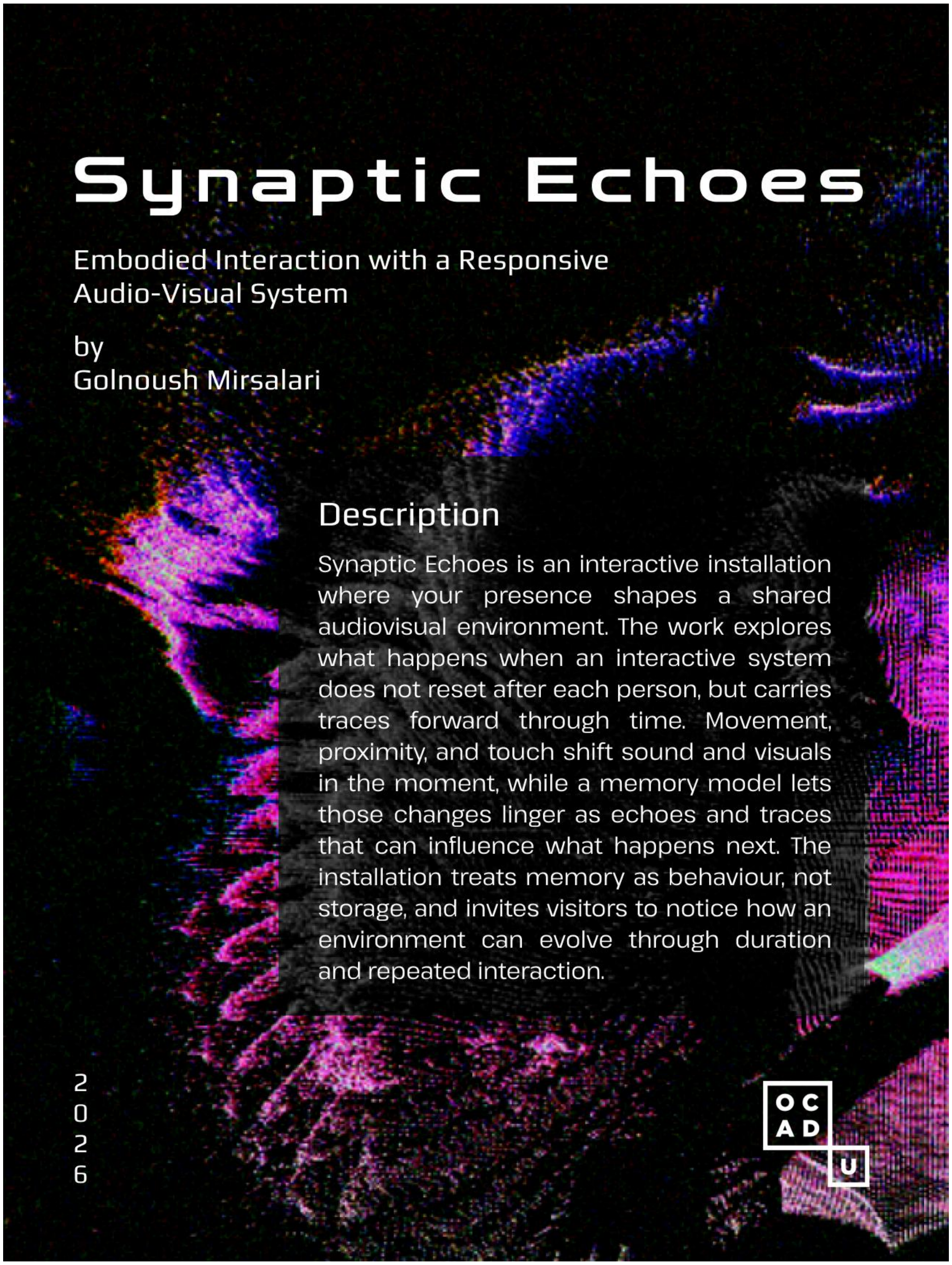


*Figure 63. The description poster for the Synaptic Echoes Installation, place on the wall during the exhibition.*

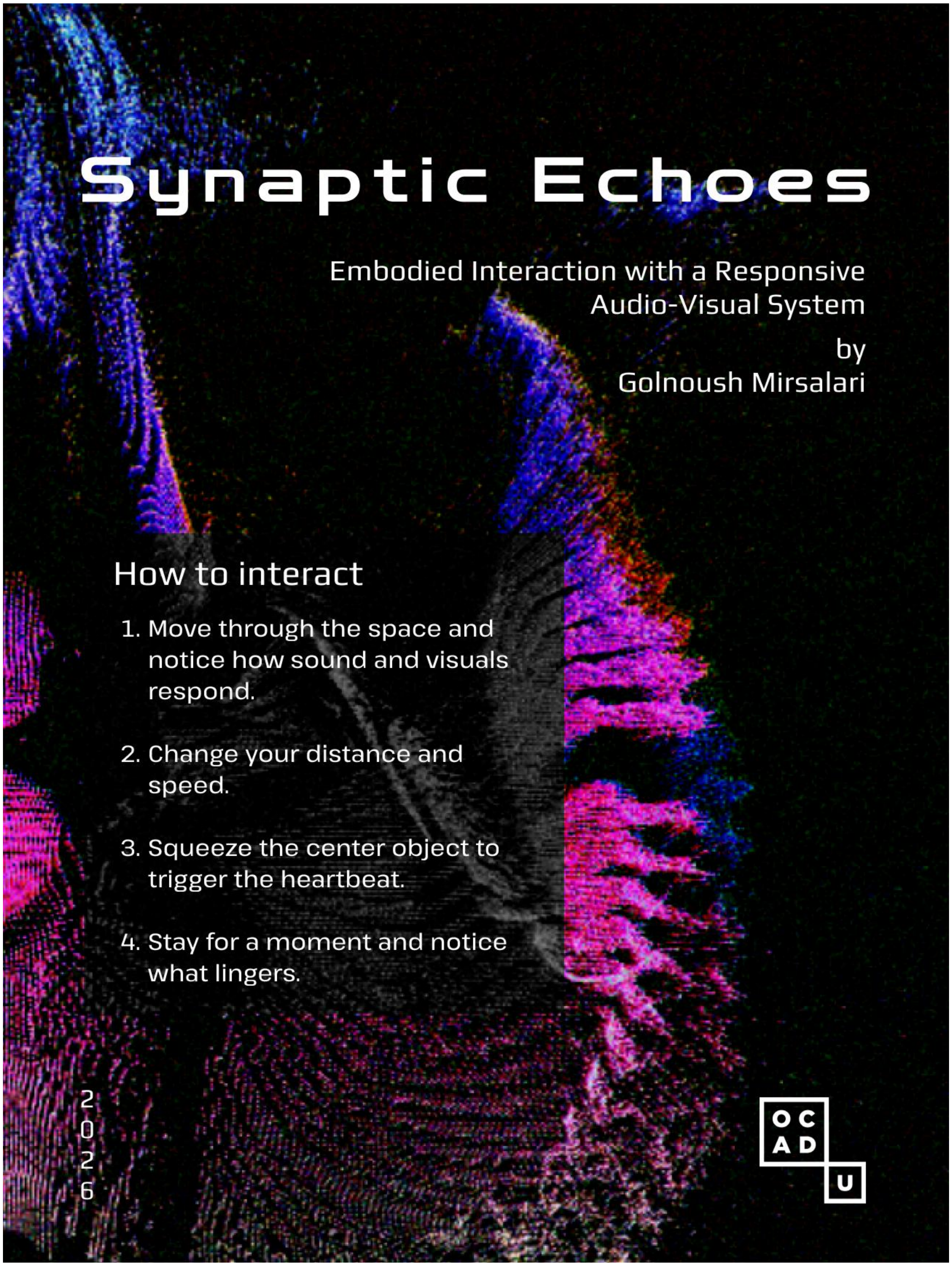


*Figure 64. poster for how to interact with the system place in the exhibition space*