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Master's Thesis
Academic Year 2025

Silent Resonance: Embodying the Tree to Design Believable N-to-N Communication Inspired by Forest Mycorrhizal Systems

Keio University
Graduate School of Media Design

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A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

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Abstract of Master's Thesis of Academic Year 2025

Silent Resonance: Embodying the Tree to Design Believable N-to-N Communication Inspired by Forest Mycorrhizal Systems

Category: Design

Summary

This thesis introduces *Silent Resonance*, a forest-inspired framework for decentralized, nonverbal N-to-N communication modeled on mycorrhizal networks. It explores how humans can connect through shared presence instead of verbal exchange. Using immersive XR, sensory rituals, and blindfolded interaction, participants embodied "trees" through synchronized movement, scent, and ambient feedback. The system—structured in three layers of physical embodiment, ecological narrative, and collective attunement—was tested with introverted, sensory-attuned users. Their subtle actions triggered responsive light and mist, simulating how forests signal stress and mutual aid. Feedback confirmed heightened awareness, identity-free resonance, and nonverbal co-presence. *Silent Resonance* proposes a new paradigm for interaction design: slow, multisensory, and ecologically grounded, inviting new rituals of connection beyond language.

Keywords:

silent resonance, N-to-N communication, nonverbal interaction, mycorrhizal communication networks, mutual aid, embodied XR design, ecological empathy, human–nature interaction

Keio University Graduate School of Media Design

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Chapter 1
Introduction

1.1. Connected but Alone

In the digital age, communication has become nearly instantaneous. Messages arrive within seconds, replies are expected immediately, and even AI can generate responses in the blink of an eye. While this speed offers convenience and efficiency, it has simultaneously eroded the more subtle dimensions of human connection. The value of presence—the act of being with someone in real time, emotionally and physically—is increasingly replaced by the logic of performance and responsiveness. As Turkle argues, "we are lonely but fearful of intimacy," and modern technologies create the illusion of companionship without the demands of relationship [4].

As communication is driven toward efficiency, we must ask: what has been lost in the process? Are we still communicating as humans—or simply exchanging information as interfaces? As Jewitt et al. suggest, the dominance of human-centered, linguistically coded communication overlooks broader paradigms— particularly those rooted in bodily, ambient, and multi-species dynamics [5]. These overlooked modes, often marginalized in favor of clarity and control, are critical to rethinking how we might reconnect with one another—not just through words, but through resonance, slowness, and shared presence.

1.2. Why Learn from Nature?

Throughout evolution, non-human species have developed slow, ambient, and collective forms of communication. From the synchronized murmuration of birds to the chemical signaling of fungi, such forms are often non-verbal, decentralized, and deeply attuned to their environments. These natural modalities challenge the

dominant paradigm of speed-driven, individuated human communication.

Ancient civilizations have long turned to nature as a model for designing rituals of connection. The Egyptians, for instance, structured sacred spaces based on celestial alignments and botanical symbolism [6]. Japanese animism, similarly, cultivates a reverence for the relational presence of trees, rivers, and stones [7], embedding communication in ambient experience rather than language.

Learning from such ecological wisdom invites us to reimagine communication as more than information exchange. It calls for a shift toward resonance: an attunement to others that transcends immediate feedback or identity recognition. As philosopher David Abram suggests, "language is born from the breath of the landscape" [8]. In other words, communication—at its root—is ecological, sensory, and embodied.

This study thus asks: Can we re-activate these ancient, non-human modes of attunement in the age of artificial immediacy? And if so, what new forms of presence might emerge?

1.3. Research Contribution

This thesis contributes to rethinking human communication through the lens of ecological systems and embodied interaction. It does so through three interconnected contributions.

First, it introduces the original concept of *Silent Resonance*—a communication model that rejects verbal exchange, identity markers, and instantaneous feedback. Instead, it centers on bodily attunement, collective sensing, and ambient co-presence. This framework challenges the assumption that meaningful communication requires clarity, directionality, or even explicit signals.

Second, it builds a bridge between ecological models—such as mycorrhizal networks—and human communication design. While such systems have been studied for their biological resilience and distributed logic, they have rarely been used as conceptual foundations for interpersonal interaction. This thesis repositions these models as metaphors and mechanisms for designing interaction beyond linguistic and visual channels.

Third, the research develops and tests a prototype communication system that

embodies these ideas. Using a phenomenological method, it explores how participants experience presence, resonance, and transformation in nonverbal, non-visual conditions. Rather than seeking universal outcomes, this approach values subjective reports, temporal rhythms, and subtle shifts in perception. This research focuses on introverted users, whose preferences for quietness, minimal stimulation, and depth of experience align with the logic of silent, ambient interaction. The proposed system integrates spatial diffusion, tactile signaling, and temporal sensing to support multi-sensory awareness and collective synchronization in non-verbal, co-present environments.

Taken together, these contributions aim to expand the scope of interaction design and human-computer interaction by inviting designers to attend to what is usually left out: slowness, silence, more-than-human references, and embodied collectivity.

1.4. Thesis Organization

This thesis is organized into five chapters, each progressively building toward an understanding of how ambient, silent interactions can foster new modes of human connection:

- **Chapter 1: Introduction** establishes the motivation for the study, questioning the current state of hyper-efficient, text-centric communication. Drawing from both non-human ecosystems and ancient cultural practices, it introduces the core concept of *Silent Resonance*, and outlines the contribution and structure of the thesis.

- **Chapter 2: Literature Review** begins with the communicative logic of forest systems—mycorrhizal networks and chemical signaling—as a model of decentralized, collective sensing. It then contrasts solo-oriented designs like Birdly and BatVision, and concludes by bridging resonance theory, phenomenology, and HCI to identify gaps in current interaction paradigms.

- **Chapter 3: Methodology and Design Process** details the design trajectory and research questions that shaped this study. It introduces the

phenomenological and iterative design methods used, and presents the design decisions and conceptual pivots that led to the final prototype.

- **Chapter 4: Design Implementation and Evaluation** presents the developed system and its evaluation in a controlled shared environment. It discusses participant feedback—especially from introverted users—and analyzes how bodily, non-verbal cues facilitated group resonance without spoken words.
- **Chapter 5: Conclusion and Future Directions** reflects on the theoretical and design contributions of *Silent Resonance*, and identifies potential applications in ambient social rituals, therapeutic design, and multispecies interaction frameworks.

Throughout the thesis, key terms such as *Silent Resonance*, *ambient attunement*, and *N-to-N communication* will be developed in dialogue with ecological metaphors and embodied interaction frameworks. Rather than offering a singular solution, this work aims to open new perspectives on how presence, slowness, and collective rhythms can inform the future of communication systems.

Chapter 2
Literature Review

While nature has often served as a metaphor in interaction design, most implementations focus on simulating individual sensory experience rather than rethinking the structures of communication itself. Projects inspired by animals or ecosystems typically center on perception, immersion, or biomimicry, rarely addressing multi-user, collective, or ambient modes of interaction. In contrast, this thesis draws on biological communication systems, particularly forest mycorrhizal networks, to propose a radically different approach—Silent Resonance—that prioritizes mutual state awareness over message transmission. This chapter builds the conceptual foundation for that shift by reviewing related work across biology, interaction design, and theory.

2.1. Mycorrhizal Networks: Forests as Communication Systems

Beneath the visible stillness of forests lies a vast and intricate system of communication: the mycorrhizal network. These underground fungal connections link trees across species, enabling them to exchange water, nutrients, and chemical signals. Suzanne Simard's foundational research revealed that these networks form decentralized, cooperative systems that prioritize mutual aid over competition [2]. Trees are not isolated entities—they share resources with kin, send distress signals, and adjust behavior based on environmental cues received from neighbors.

This model offers a radically different paradigm from conventional human communication. Rather than relying on explicit symbols or direct dialogue, the forest network operates through ambient, non-verbal, and state-based interaction. Importantly, the structure is **N-to-N**—every tree may simultaneously act as sender,

receiver, and relay. Unlike centralized message systems, this fosters resilience, subtlety, and a distributed sense of presence. The forest becomes a living, sensing collective, capable of coordinated action without conscious messaging [9, 10].

The diagram below visualizes Simard's seminal study: 67 Douglas-fir trees connected across a 30×30 meter plot via mycorrhizal fungi. Green shapes represent trees (sized by diameter), and colored lines indicate fungal connections. Notably, the most connected tree (arrow) links to 47 others, suggesting a complex communicative web rather than isolated dyads.

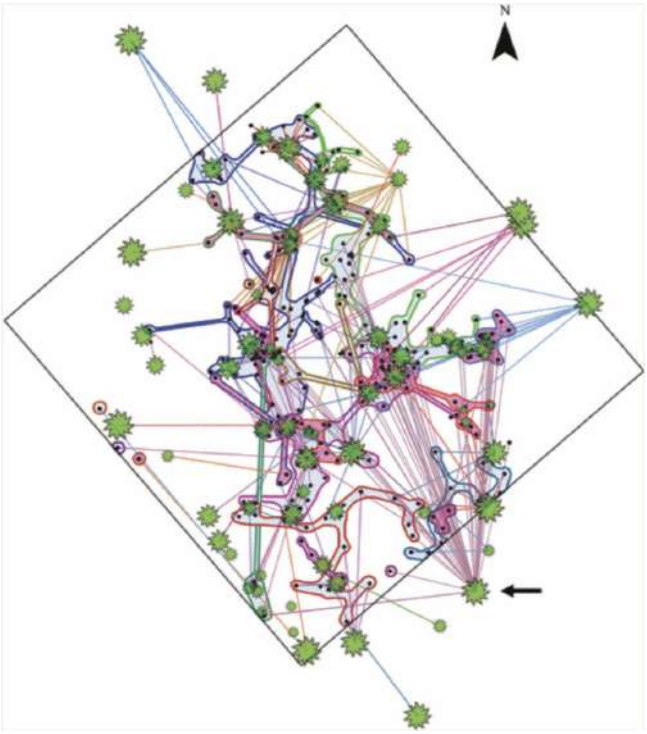

Figure 2.1 Top-down view of fungi and 67 Douglas-fir trees in a 30×30 m plot. Green shapes are trees, sized by diameter. Lines show fungal connections—arrows point to the most connected tree. (Image adapted from AskNature [1], based on research by Simard et al. [2])

This model inspires a shift from message transmission to collective sensing in human design. Mycorrhizal communication emphasizes presence over speed, mutuality over identity, and ecological feedback over centralized control. As such, it becomes a biological metaphor for reimagining human-to-human systems—not as di-

alogues between egos, but as shared resonant states among beings-in-environment.

2.1.1 Interspecies Signaling and Forest Defense

Tree communication plays an active role in collective defense, extending far beyond passive resource exchange. This defensive signaling can be divided into five interconnected processes, involving both mechanical and chemical sensing (see Figure 2.2).

(1) Detection of Mechanical Stress. When branches touch—due to wind or contact—trees perceive mechanical stress through pressure or vibration. These biomechanical signals prompt physiological shifts, such as the modulation of growth rates or cell wall rigidity [3].

(2) Localized Defense Activation. Touch-sensitive responses often trigger local chemical changes: for instance, trees may slow growth, increase lignin production, or alter leaf chemistry to deter herbivores. These defensive shifts occur even in the absence of direct herbivory.

(3) Emission of Volatile Organic Compounds (VOCs). In response to environmental threats—including herbivore attack—trees emit airborne VOCs, such as methyl salicylate and terpenoids. These compounds diffuse through the forest air, acting as chemical messengers.

(4) Neighbor Responses to VOCs. Nearby conspecific trees detect VOC cues and activate their own immune pathways preemptively. In some cases, VOCs also attract predators or parasitoids of herbivorous insects, further reinforcing community defense.

(5) Mycorrhizal Network Communication. Belowground, trees are linked via mycorrhizal fungi that transmit signals and nutrients across distances. These "wood-wide webs" allow for the diffusion of stress-related cues even beyond the reach of airborne VOCs, creating a redundant, multi-channel communication system.

Together, these layered processes constitute a decentralized form of interspecies awareness, where information is distributed via both air and soil. The forest thus operates as a sentient ecology: sensing threats, modulating local and systemic responses, and enabling collective resilience without centralized control.

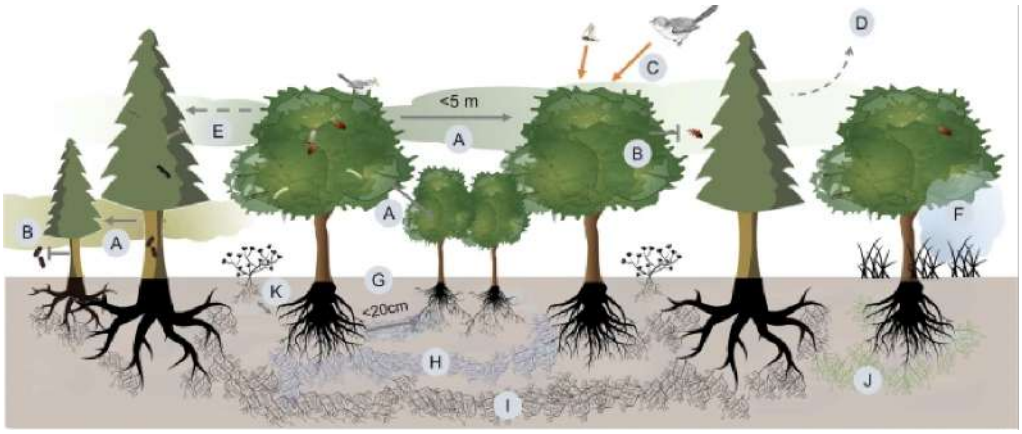

Figure 2.2 Tree defense signaling via VOCs and mycorrhizal networks. Mechanical stress triggers local defense (A–B), VOCs signal neighboring trees and predators (C–F), and underground fungi facilitate further exchange (G–J). Adapted from Rasheed et al., 2023 [3].

2.2. Limits of Perception-Driven Design

While many projects in interaction design take inspiration from animals or natural phenomena, they often focus on augmenting human perception rather than transforming the structure of communication itself. These designs prioritize individual immersion, enhancing the sensory fidelity of a single user, yet rarely interrogate how meaning, presence, or collectivity are constructed across multiple bodies in shared space.

2.2.1 Birdly — Embodying Flight

Birdly, developed by SOMNIACS, enables users to experience what it feels like to fly like a bird. The user lies on a motorized platform, dons a VR headset, and controls motion through arm flapping and body tilt. The system integrates wind simulation, full-body actuation, and immersive visuals to simulate realistic flight navigation (see Figure 2.3).

Despite its biological inspiration, Birdly centers on solo immersion and goal-oriented performance. The interface prioritizes mastery, speed, and visual feed-

back, aligning with gamification logics rather than ecological attunement. The interaction is expressive, yet remains individual and unidirectional, lacking shared affect or communication.

Figure 2.3 Birdly, an immersive flight simulator that mimics avian motion through VR and full-body actuation. (Image source: Birdly VR by Somniacs, used under fair use for academic commentary)

2.2.2 BatVision — Echo Perception

BatVision is a speculative project exploring how humans might perceive space through sonic reflections, similar to echolocation in bats. Users wear a headset that emits and receives audio pulses, constructing spatial awareness from reflected sound cues.

The project challenges visual dominance by enabling non-visual navigation. However, the focus remains on individual sensory augmentation rather than mutual attunement. Like *Birdly*, it treats perception as a challenge to overcome—

Figure 2.4 BatVision, a project investigating human echolocation through wearable technology. (Image source: BatVision by Design Research Lab, used under fair use for academic commentary)

Figure 2.5 Visual interface of BatVision showing sound-based spatial reflection. White dots represent echo-mapped surfaces, while yellow insects serve as navigational markers. (Image source: BatVision, used under fair use)

highlighting novelty and adaptation—without fostering relational presence or co-experience.

2.3. From Perception to Resonance

Birdly and BatVision exemplify a larger trend in nature-inspired design: perception is enhanced, but the structure of communication remains unaltered. These systems conflate embodiment with control, prioritizing fidelity over relationality. Sensory immersion becomes an end in itself, often reinforcing individualistic, linear, or anthropocentric logics.

This thesis proposes a shift. Rather than extending perception, it seeks to transform the *logic of interaction*—from directed input-output models to decentralized states of shared attunement. By drawing on the communicative ecology of forests—where trees sense, signal, and synchronize without centralized control—design can move toward collective sensing. Such systems resist translation into goals or feedback loops; instead, they cultivate ambient, non-verbal, identity-free presence across distributed agents.

Projects like *Birdly* and *BatVision* exemplify this trend: they create rich, embodied simulations through visual, haptic, and auditory fidelity, often centered on a single user navigating a foreign perceptual world. While these systems succeed in generating affective engagement, they largely operate within a framework of performance, goal-directed navigation, and sensory substitution.

Such immersive interfaces are built on a logic of fidelity and control. The user is asked to master a new sensorium, often through analogues to flight, sonar, or motion. However, these experiences tend to remain anthropocentric, emphasizing spectacle over transformation. As Jewitt et al. (2025) note, many digital systems still "replicate human-centric communication modes," rather than inventing new relational logics [5]. Even in speculative formats, the individual remains the site of meaning-making and action.

This research proposes a shift: from *immersion* to *resonance*. Where immersion centers on presence within a simulated space, resonance emerges from being-with others in a shared, affective field. It is not about adopting another sensorium,

but about allowing one's internal state to become porous to the states of others—across species, interfaces, or systems.

Resonance privileges latency over response, ambiguity over clarity, and attunement over mastery. It unfolds not through directed control but through mutual modulation, as seen in the non-verbal coordination of tree networks. The goal is not to simulate flight or echolocation, but to foster a collective field of sensing that resists translation into message or command.

This shift aligns with the ecological logic of forest communication systems. Trees do not *send messages* in the traditional sense; they participate in ambient networks of mutual awareness and chemical gradients. To move from immersion to resonance is thus to reject the spectacle of sensing and embrace the subtlety of relational presence.

2.4. Bridging HCI, Phenomenology, and More-than-Human Design

As interaction design increasingly grapples with ecological, relational, and post-anthropocentric challenges, the boundaries between Human–Computer Interaction (HCI), phenomenology, and more-than-human design are beginning to blur. Traditional HCI has long prioritized usability, performance, and user-centered control. Yet this logic often overlooks the experiential, relational, and ontological dimensions of being-with technologies, especially within multispecies or multisystem environments.

Phenomenology offers an alternative entry point—foregrounding lived experience, embodied perception, and situated intentionality. Rather than treating perception as data processing or stimulus–response, phenomenology frames it as an unfolding relation between self, body, and world. From this perspective, technologies are not neutral tools but mediators of relational experience, capable of shaping affect, temporality, and meaning.

Building on this, more-than-human design expands the scope of who or what counts as a participant in interaction. Inspired by feminist theory, STS, and posthumanism, it challenges anthropocentric assumptions and invites designers to attend to plants, animals, microbes, and machines not as metaphors or resources,

but as co-agents in situated ecologies [11, 12].

Bridging these traditions requires a fundamental rethinking of interaction—not as a dialogue between user and system, but as a situated, embodied, and affective co-presence. Phenomenological methods enable us to access pre-reflective and multisensory dimensions of experience, while more-than-human design shifts our ethical and epistemological orientation toward nonhuman subjectivities.

Within this framework, resonance emerges as a powerful conceptual and design tool. Rather than emphasizing mastery, message clarity, or sensory substitution, resonance centers on mutual modulation, ambiguity, and shared attunement across difference. In this view, design becomes less about enabling human action and more about cultivating relational presence—among bodies, systems, species, and environments.

2.5. Summary and Research Aim

While the previous sections examined how forest systems, perceptual design, and more-than-human perspectives challenge human-centric interaction models, this thesis is ultimately anchored by a central aim and design question.

Research Aim. To explore how non-verbal, presence-based, decentralized N-to-N communication can be designed through the ecological metaphor of forest systems.

Key Question. How can we embody the ecological logic of tree communication to foster identity-free, state-driven human connection?

This inquiry seeks to move beyond symbolic exchange or sensory augmentation toward interaction modalities grounded in ambient mutuality. Drawing inspiration from mycorrhizal networks, where awareness is distributed and communication is non-directed, the thesis asks how such a paradigm might reshape the design of human-to-human systems—especially in ways that decenter individual identity, intention, and control.

Rather than mastering a new sensorium, this approach encourages relational attunement: to design for presence, latency, and resonance rather than information transmission. It challenges both technological and epistemological norms, calling for a fundamentally different logic of connection—one that is ecological,

collective, and more-than-human.

This conceptual framework sets the stage for the next chapter, which outlines the design methodology used to explore, prototype, and evaluate such communicative states in practice.

Chapter 3
Silent Resonance

3.1. What Is Silent Resonance?

Silent Resonance is a new paradigm of sensing and being together—an interaction philosophy inspired by how trees connect, communicate, and respond within a forest. Unlike human conversations that rely on messages and directed attention, forests operate through a decentralized logic. Trees interact not through identity or instruction, but through ambient conditions, chemical signals, and subtle state shifts across shared networks.

This project translates such *forest logic* into a new human experience design. In the wild, trees are connected via root systems and mycorrhizal fungi, allowing them to signal stress, share nutrients, and respond to environmental cues through non-verbal, multisensory communication. These mechanisms are:

- **Decentralized**: no central control
- **Directionless**: no speaker or receiver
- **Diffuse**: feedback takes time and propagates
- **Identity-free**: nodes interact without fixed roles

To bring this into a human context, *Silent Resonance* proposes an **N-to-N** model of interaction. Rather than creating dialogues between individuals, the system cultivates shared states that ripple across a group through bodily presence and ambient cues. The project is not interested in language or symbolic meaning, but in physiological attunement and environmental sensitivity—like trees adjusting to the wind, participants attune to each other without words.

> "It's not a conversation, but a shared state. Not messages, but ambient sensing.
> Not one-to-one, but many-to-many. Not language, but bodily presence."

Silent Resonance ultimately shifts the goal of interaction design—from conveying meaning to *creating co-presence*. In a world increasingly saturated with speech and screens, this work asks: What if we could be together through silence?

3.2. Becoming the Tree

To evoke forest logic within human participants, the *Silent Resonance* system constructs a three-layer immersive reality. Each layer scaffolds a different dimension of the tree embodiment experience—physical, ecological, and social. Together, they build a believable yet unfamiliar world where participants temporarily "become trees."

3.2.1 Physical Embodiment

The first layer centers on the body. Participants wear eye masks and enter a sensorily-controlled space. Soundscapes mimic forest environments, while slow bodily movements are guided by ambient rhythm. Without visual input, participants begin to sway gently, attuning to subtle sensations and group rhythm. The body becomes an interface for transformation.

> Participants *feel like a tree*—not metaphorically, but somatically—through posture, rhythm, and atmospheric cues.

3.2.2 Ecological Narrative

The second layer introduces an environmental logic. Mist, low light, and ambient forest sounds immerse participants in a simulated forest night. These stimuli are not decorations but functional signals—participants gradually learn to respond, not unlike trees sensing drought, light, or threat. A light flicker might indicate a shift in the collective state; a burst of mist signals stress dispersion.

> In this layer, participants experience ecological feedback systems such as *resource sharing* and *group resonance*.

3.2.3 Socialized Tree Reality

The final layer enables *multi-user interaction*. Here, each participant's state influences the others—not through commands, but via silent ambient responses. There is no fixed role, no leader, no direction. A participant who becomes still might trigger a light dimming; several silent bodies may collectively trigger mist. The logic is emergent and non-verbal.

> Participants do not "communicate" but co-exist in a decentralized, identity-free space.
> They *live* the N-to-N logic, not as trees pretending, but as humans resonating.

This three-layer construct is not just an immersive space—it is a reconfiguration of social interaction principles. Where most systems seek to clarify intention, *Silent Resonance* seeks to amplify ambiguity, patience, and embodied attunement.

3.3. Pre-Test: Embodying Tree Awareness in VR

Before developing Silent Resonance as a shared ambient sensing system, a pre-test was conducted using VR technology to explore the idea of identity transformation through sensory immersion. The goal was to investigate how human participants might shift their perception by embodying the forest's underground logic systems.

The XR experience, titled *Whispers of the Forest*, invited participants to wear a headset and enter a sensory-controlled environment. Instead of a narrative or instruction-based approach, the experience centered on ecological metaphors and gradual sensory engagement.

The system translated three foundational modes of tree communication into interactive and visual forms:

- **Root Connections**: Participants stood or moved slowly to mimic root expansion. Low-frequency sound vibrations and ground-level lighting emphasized grounding and presence.

- **Mycorrhizal Networks**: Spatial visuals showed glowing filaments that connected participants to others, creating a feeling of underground interconnection.
- **Chemical Signaling**: Participants observed particle-like flows and sound cues that represented invisible exchanges of environmental data—akin to volatile organic compounds in forests.

Figure 3.1 Scenes from the XR prototype "Whispers of the Forest," demonstrating participant interaction and visual representations of tree logic.

The aim was not to simulate trees literally, but to translate forest logic into a bodily and sensory state. Participants were asked to interact through slow movements and awareness, gradually tuning into their surroundings and the shared ambience. Feedback showed that participants were able to experience a form of "silent connection," reporting sensations of resonance, grounding, and non-verbal awareness.

"It didn't feel like a game. I wasn't trying to do anything. But I could

> feel something shifting around me, like I was rooted with others." — Participant Feedback

This prototype laid the groundwork for the Silent Resonance system. By embodying forest-inspired logic in a human context, it became possible to imagine interaction not as task-driven exchange, but as a shared perceptual field. The concept of "silent resonance" thus began not as a social tool, but as an embodied state of co-existence.

3.4. First Prototype

In this prototype, participants sat in chairs arranged in a circular formation, each blindfolded and physically connected to others via a thin string. They did not know how many others were present, nor the layout of the space. The setup mimicked tree root systems—allowing participants to sense subtle vibrations and tensions through the string, just as trees detect nearby life underground.

This experiment was an early step in designing for *Silent Resonance*: a mode of nonverbal, embodied presence. The key goal was to explore how sensory input—especially haptic and proprioceptive—could create a shared state of spatial awareness without language or sight.

Participants reported heightened sensitivity to tension and stillness. The inability to locate others visually forced attention onto the smallest shifts in the string, mirroring how trees detect disturbances through root pressure or density changes.

However, real tree communication is not one-to-one. Instead, it occurs across complex networks in slow, ambient, and decentralized forms. This limitation inspired the transition toward a more distributed, multi-user prototype—exploring shared resonance over networks rather than isolated dyads.

Key Experience Goals:

- Evoke embodied awareness through tactile feedback and subtle physical cues.

Figure 3.2 Silent Resonance Chair setup: Participants were blindfolded and connected through a string across four chairs.

Figure 3.3 Left: Detail of the full room setup, showing the physical string connections; Right: Close-up of a participant during the interaction.

- Reduce verbal or narrative framing, allowing participants to tune into state-based presence.
- Experiment with the role of uncertainty in forming connection and attention.

Design Reflections: Participants described a sense of "quiet safety" and heightened attention. However, because the system relied on tension across strings, it was limited to dyadic resonance and lacked clear shared triggers. The next prototype aims to scale these dynamics across a network, enabling emergent multi-user communication.

3.5. Second Prototype

3.5.1 User Selection

In many contemporary social systems, particularly those mediated by screens and language-driven interfaces, extroverted modes of expression are often privileged—fast-paced, vocal, performative. This tends to marginalize individuals who connect in slower, less overtly expressive ways. *Silent Resonance* aims to reverse this logic by foregrounding subtlety, presence, and embodied stillness as valid and meaningful modes of communication.

Introverted individuals—who often thrive in low-stimulation environments, rely on sensory attunement, and seek depth over breadth in social interactions—offer unique affordances for this design. They are not "less social," but differently social: more resonant with the ecological metaphors of forests, where vast underground networks support non-verbal, distributed collaboration. Thus, introverts were not merely convenient test participants—they were the conceptual core of a system that seeks to imagine a different kind of collective connection.

To ensure alignment with these design intentions, a **Pre-Test Personality Questionnaire** was developed and distributed to screen participants based on their sensory sensitivity and introverted tendencies. The questionnaire consisted of ten statements rated on a scale from 1 (Strongly Disagree) to 5 (Strongly Agree), targeting traits such as emotional attunement, environmental sensitivity, and a preference for non-verbal engagement.

Key statements included:

- "I prefer quiet environments over busy social spaces."
- "I need alone time to recharge after social interactions."
- "I find comfort in slow, non-verbal experiences."
- "I often sense how others feel without needing words."
- "I value silent moments shared with others more than casual conversation."

Participants' responses were summed (maximum score: 50), and those scoring above 45 were identified as most aligned with the desired user profile. From the initial screening pool, three such participants were selected for immersive prototype testing. This filtering process ensured that users were predisposed to engage meaningfully with subtle, multisensory, and ambient forms of collective experience—mirroring the quiet, resonant dynamics observed in natural forest systems. The full list of questionnaire items is provided in Appendix C.

3.5.2 Multisensory Interaction

The second prototype explored multisensory non-verbal interaction inspired by the chemical and subterranean communication of trees. The environment was designed as a darkened room, where participants—blindfolded—relied on touch, proximity, and intuition rather than sight or speech. When two or more participants made physical contact, a trigger mechanism activated an aromatic mist, symbolizing chemical signaling within forest root systems. Simultaneously, green light projections filled the space, evoking a shared atmospheric resonance. This coupling of scent and light not only heightened bodily awareness but also reinforced the metaphor of trees exchanging information silently through decentralized networks.

Participants entered the dimly lit room in silence and were instructed to sit back-to-back in the center, avoiding verbal communication. The space was filled with green ambient light and occasional scents representing forest life, while their attention was directed toward their sense of touch, smell, and spatial awareness.

Figure 3.4 Initial setting: participants sat back-to-back without speaking, engaging only via shared space and senses.

After a few minutes of seated stillness, subtle environmental shifts (light and scent) occurred, prompting participants to slowly raise their hands and connect with others. This moment often became the turning point where trust and group awareness emerged, echoing the silent, symbiotic growth patterns of trees in nature.

In the final phase of the experience, participants stood and engaged in a slow-paced, touch-guided interaction in the green-lit space, blindfolded. Through non-verbal hand movements, they attempted to connect with others, mimicking underground tree networks reaching out through their roots.

3.5.3 Feedback and Symbolic Reflections

After the session, participants completed a Post-Test Feedback Questionnaire to reflect on their sensory experiences, emotional connections, and interpretations of

Figure 3.5 Sensory prompt initiated: green light stimulation paired with nature-inspired scent triggered interaction.

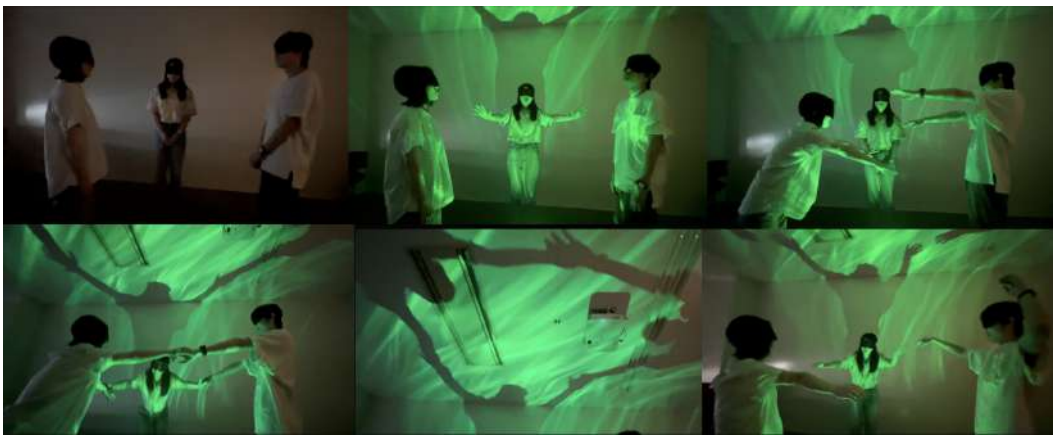

Figure 3.6 Participants began exploring the space blindfolded, relying on touch to connect with others.

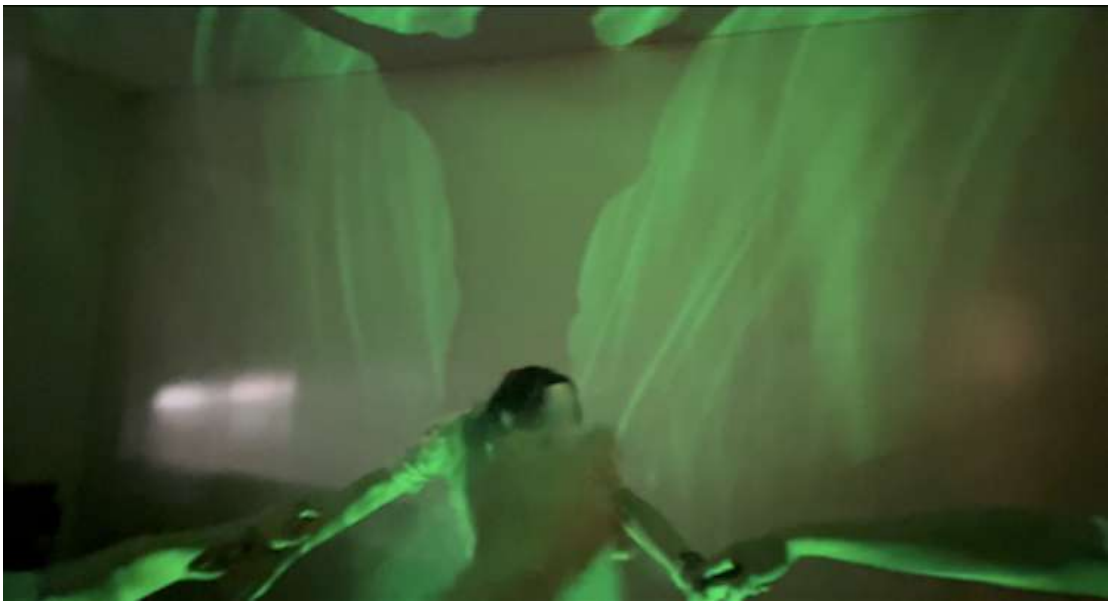

Figure 3.7 Aromatic mist is released in response to physical contact between participants, simulating chemical signaling between trees.

the symbolic environment (see Appendix D).

The feedback revealed that participants experienced a strong sense of connection through tactile and olfactory cues. One participant wrote, "I found my members — that is, another tree," indicating a successful metaphorical transference of the forest communication logic. Another commented on the power of raising hands in unison, expressing a connection "I can't see."

These findings support the hypothesis that immersive, non-verbal environments can foster deep inter-human connection by stimulating dormant senses and removing language as a barrier. The participants' responses aligned with the logic of tree communication: rooted, indirect, sensory, and profoundly communal.

3.5.4 Sensory Analysis and Design Reflections

The second prototype provided an opportunity to critically reflect on the role of multisensory cues in shaping non-verbal social experiences. Each sensory channel—touch, smell, and visual immersion—was deliberately isolated from verbal input, allowing participants to rely on instinctual forms of engagement.

Tactile interaction proved to be the most immediate and universally understood language within the space. The absence of sight and speech heightened participants' sensitivity to skin contact and spatial proximity. Subtle gestures such as holding hands, raising arms together, or gently brushing against another's body were often interpreted as intentional signals of recognition and solidarity. This mirrors the way tree root systems transmit signals through underground contact, reinforcing the prototype's ecological metaphor.

Olfactory cues, introduced through aromatic mist, enhanced the emotional tone of interactions. Participants reported feelings of calm, alertness, or curiosity triggered by the shifting scents. The use of scent as a form of "chemical communication" was effective in stimulating subconscious responses and was often associated with pivotal turning points in group engagement. The unpredictability of scent release also contributed to a sense of mystery and attentiveness.

Visual elements, such as ambient green light and dynamic projections, acted less as narrative tools and more as atmospheric scaffolds. These visuals framed the experience as distinctly non-domestic and symbolic, establishing a shared mood without dictating meaning. The consistent use of green hues encouraged associations with forest environments, vitality, and organic growth.

From a design standpoint, the experience highlighted the effectiveness of sensorial minimalism—the decision to strip away verbal communication, explicit rules, or goal-driven tasks in favor of open-ended bodily exploration. This allowed participants to project their own meanings onto the interaction, leading to diverse yet coherent interpretations rooted in their personal sensibilities.

One key insight from this prototype is the power of designed ambiguity. By avoiding prescriptive interactions, the prototype encouraged improvisation and co-creation. Participants were not simply users of a system, but active agents shaping the communicative network with their bodies and senses.

This sensory and symbolic openness aligns well with the needs of introverted participants, who often thrive in low-stimulation, reflective environments. Rather than confronting them with overstimulation or rapid input-output cycles, the prototype offered slow, layered stimuli that invited introspection and subtle connection.

Participant feedback from post-test questionnaires highlighted the effectiveness

of the multisensory system in cultivating non-verbal connection. Heightened sensory awareness—particularly through touch and olfactory cues—allowed participants to perceive each other's presence even without sight or speech. As one participant expressed, "Even though I can't see them, I can feel them trying to find me."

Connection moments often emerged when actions synchronized, such as two people holding hands or moving in rhythm. These gestures were perceived not as accidental, but as meaningful signals of resonance. Another participant reflected: "There's no verbal communication — only touch, like plants."

The green lighting and aromatic mist were consistently interpreted as signals of unity, organic vitality, or calming states. Several participants described the space as becoming "alive" when scent was triggered—interpreting it as a form of nonverbal feedback from the system, echoing their collective mood. One noted: "I found my members — that is, another tree."

These reflections reinforced the prototype's aim: to design a space where subtle, embodied presence—not speech—becomes the primary language of social attunement.

3.5.5 Limitations and Transition Toward Collective Forest Logic

While the second prototype successfully enabled moments of silent, embodied connection—often triggered by synchronized gestures or multisensory cues—it also revealed notable limitations in the scope and structure of social engagement.

Most interactions remained dyadic or confined to small, localized clusters. Despite the ambient, non-verbal environment, participants frequently defaulted to familiar social patterns: seeking direct partners, relying on reciprocal gestures, and mirroring conventional cues. This tendency suggested that participants were still operating within frameworks of individual-to-individual interaction, rather than engaging in a shared, distributed awareness akin to an ecosystem.

This observation highlighted a core limitation: while users could experience brief resonance, the interactions lacked **collective integration**. The system did not yet support an emergent, ambient social mesh in which presence and

attunement extend beyond pairwise exchange.

In response, the design direction evolved toward what may be termed a **forest logic**—a paradigm inspired by how trees in natural forests communicate not through direct signaling, but via diffuse, systemic awareness mediated through root networks and shared chemical signals. This metaphor offered a compelling shift: from isolated interaction to decentralized resonance.

The final prototype was thus conceived as a collective, multisensory ecosystem, wherein each participant's subtle embodied state—movement, stillness, proximity—could influence the shared sensory field. Rather than targeting explicit responses, the space would amplify implicit states, fostering a field of mutual awareness without needing direct action or recognition.

Ultimately, this transition reframed connection as a shared atmosphere rather than an intentional message—a silent, ambient resonance that unfolds laterally and organically, much like trees communicating stress through mycorrhizal webs. This became the conceptual foundation for the final prototype.

Chapter 4
Proof of Concept

This chapter presents the final prototype of the *Silent Resonance* system and its evaluation through a small-scale phenomenological user study. The aim was to assess whether the experience effectively conveyed themes of nonverbal resonance, multisensory embodiment, and decentralized interaction inspired by forest ecologies.

It begins with a description of the prototype's conceptual foundations and technical configuration, followed by a phase-by-phase breakdown of interaction dynamics. Building on this, the chapter details the study design and key findings, drawing on both quantitative and qualitative data. The analysis considers temporal unfolding, internal transformation, and the broader implications of non-verbal co-presence, as shaped by iterative faculty feedback.

4.1. Final Prototype

Building upon the limitations revealed in Prototype 2, the final prototype—Silent Resonance—shifts the design paradigm from dyadic interactions to a decentralized, ecologically-inspired system of ambient awareness. Inspired by forest ecosystems and their distributed, silent communication through mycorrhizal networks and volatile organic compounds (VOCs), this prototype simulates collective sensory resonance rather than targeted pairwise signaling.

4.1.1 Entering the Forest

Before the interaction begins, participants are guided into a completely dark, sensory-controlled room. Each person wears an eye mask, making them unaware of how many others are present or where others are situated within the space.

This condition evokes the feeling of trees in a forest at night—still, rooted, and surrounded by ambient sounds of wind and nature. Importantly, no verbal instructions are given. Only ambient sensory cues—such as changes in soundscape or air flow—are available to guide behavior.

This setting initiates a three-layered immersive experience designed to simulate forest dynamics through bodily and sensory engagement:

1. Physical Embodiment — Participants begin by slowly swaying, mimicking the motion of wind-blown trees. This movement is subtle, rhythmic, and meditative, reinforcing the notion of becoming "tree-like" through posture and stillness. These bodily states set the tone for entering a non-verbal, resonant environment.

2. Ecological Narrative — While blindfolded, each participant must sense and respond to unseen others through non-visual and non-verbal means. This heightened awareness mirrors the ecological "forest logic" observed in natural systems, where organisms adjust to balance, stress, and recovery in subtle, decentralized ways.

3. Socialized Tree Reality (N-to-N) — In this emergent interactional model, every participant's action affects the whole system. Rather than following a leader or initiating direct contact, individuals become part of a silent, distributed network of embodied presence. Connection becomes ambient, identity-free, and communal—akin to mycorrhizal communication in forest ecologies.

Together, these three experiential layers form the foundation of the final prototype, grounding it in symbolic, ecological, and sensory realism.

4.1.2 Ecosystem Translation

In the Silent Resonance system, biological mechanisms observed in forest ecologies are translated into embodied, sensory-driven human interactions. This design draws direct analogies between tree behavior and participant response, simulating ecological signaling through subtle cues and states of presence.

- **Wind moves tree branches** → Wind sound in the room cues participants to slowly raise and sway their arms. This initiates a passive, ambient reaction to the surrounding environment.

- **Branches touch each other** → As participants sway, arms occasionally touch. This simulates mechanical contact between trees during wind events.
- **Chemical signals (VOCs) are released** → Upon touch, a light mist spray is triggered, mimicking the emission of local chemical signals (e.g., defensive VOCs).
- **Neighboring trees sense VOCs and adjust** → Participants sensing mist begin to withdraw their arms, indicating a state-based behavioral shift influenced by non-verbal feedback.
- **Forest enters adaptive silence** → All participants eventually come to stillness with lowered arms, mirroring forest-wide homeostasis and communal equilibrium.

This chain of interactions reflects how ecological processes are embodied in human experience through ambient, decentralized signaling. The design avoids explicit communication, instead fostering a form of attunement rooted in sensory metaphor and collective regulation.

4.1.3 System Logic

The Silent Resonance system models collective forest behavior through a staged sequence of embodied interactions. Each stage reflects ecological processes—such as sensing, signaling, and recovery—via ambient changes in light and mist. Rather than explicit communication, shifts in participant behavior arise from shared environmental cues.

Initial Stage: Dormant Forest The experience begins in total stillness. Participants stand silently in darkness, their bodies inert and unrevealed. The space remains unlit, symbolizing a dormant forest before activation. No sensory stimuli are introduced, reinforcing a baseline of calm.

Movement Initiation: Activated Sensing Triggered by ambient wind sounds, participants begin to sway gently. This marks the "awakening" of the forest, as

bodies respond to non-verbal cues. A soft green light flows through the space, signifying active yet non-alerted sensing—trees responding to subtle environmental changes.

Partial Touch: Local Alert Phase As one or two participants make accidental or exploratory contact (e.g., brushing arms), a local disturbance is registered. This event triggers a split lighting pattern—green mixed with red—mimicking how trees locally detect physical interference. The system enters a state of early alert.

Full Contact: Stress Activation Once a majority of participants engage in touch, the environment responds with a full red lighting state. This simulates the activation of a collective stress response, as in a forest where multiple organisms are simultaneously disturbed. The atmosphere becomes more tense, yet remains silent.

Mist Release: Defensive Signal A manual mist trigger is introduced—either by the system or facilitator—releasing a scentless vapor that spreads across the room. This simulates the release of volatile organic compounds (VOCs), mimicking trees' defense signals. Participants receiving the mist may begin to subtly withdraw, embodying a shared chemical communication.

Freeze: Collective Recovery As mist circulates, all participants slow down and return to stillness. A blue light fills the space, denoting collective freezing. This signals the beginning of a forest-wide adaptation phase, promoting silence, equilibrium, and ambient cohesion.

Restart: New Sensory Round After sufficient stillness, the light gradually shifts to green again. The cycle resets, and the space re-enters a state of ambient sensing. This cyclic behavior models N-to-N logic: each new round of movement emerges not from central instruction but from shared environmental re-attunement.

The space reflects the collective state of the trees. This prototype simulates the forest's defense mechanism—when one tree is disturbed, it triggers a nonverbal ripple through light and mist, alerting others and restoring balance.

4.2. Phases of Interaction

4.2.1 Phase 1: Awakening

Figure 4.1 Participants swaying in green-lit space during Phase 1: mimicking the awakening of the forest sensing system.

Participants begin to sway their arms in response to the simulated sound of wind, triggering the system's first phase of activation. This slow, coordinated movement mirrors the natural behavior of trees stirred by wind, initiating ambient awareness.

As arms begin to move, the space lights up with dynamic green light flows. This color and motion signal the awakening of the forest's sensing network. The more synchronized and sensitive the participants are to the environmental sounds, the more quickly and vividly the green light spreads—emphasizing ambient reactivity.

This initial phase demonstrates passive responsiveness and prepares participants to enter deeper layers of multisensory interaction in the system.

4.2.2 Phase 2: Interference


Figure 3.12 Red light begins to appear as participants make local contact, indicating early interference.

This stage simulates the mechanical interaction between tree branches—branches brushing or bumping into one another. The red signal alerts the system that a threshold of physical disturbance has been reached.

This minimal yet impactful interaction generates a chain reaction of alert signals. The amount of contact does not require speech or commands; instead, it reflects the intuitive communication of trees through sensory cues—prompting an ecological, embodied response.

4.2.3 Phase 3: Alert

As physical touch spreads among the majority of participants, the entire space shifts to a vivid red illumination. This transformation visually represents a forest-wide alert condition—where densely interconnected trees propagate alarm signals rapidly in response to escalating disturbance.

In this phase, participants' blindfolded movement synchronizes into a collective rhythm as they all engage in physical contact. The installation encodes this as a synchronized red glow, signifying systemic stress and unified defense response across the simulated network.

This stage highlights how forests, like participants, are interconnected through subtle sensory signals. The escalation to full red mimics a forest's maximum alert threshold under threat.

Figure 4.2 Most participants have made contact, triggering red glow.

Figure 4.3 The space turns fully red as participants enter collective contact, simulating a full-system stress alert.

4.2.4 Phase 4: Mist Signals

Mist is released into the space, simulating volatile chemical signals (VOCs) in trees. Participants begin to withdraw arms, embodying a silent, sensory-driven feedback loop.

Figure 3.15 Mist released into the space simulates volatile organic compounds (VOCs) in trees. Participants begin to withdraw arms, demonstrating a silent, chemically-induced retreat in collective response.

4.2.5 Phase 5: Recovery

All participants come to a still pose. The space gradually shifts into a cool blue hue, signaling the end of the interactive loop.

This stage embodies the forest's return to equilibrium following a disturbance. The blue lighting and collective stillness reflect a rebalancing phase — where communication ceases, and calm is restored. Participants, like trees after a period of stress, enter a shared state of quiet recovery. No longer guided by external stimuli, the group synchronizes in silence, highlighting a moment of mutual attunement and post-stress integration.

This final moment reinforces the system's cyclical nature — from ambient activation to full alert, and ultimately to balance — echoing the regenerative rhythms of forest ecosystems.

Figure 4.4 Participants stand still in a blue-lit environment, representing a return to homeostasis. This final phase visualizes a forest's recovery cycle through shared stillness and silent sensory resonance.

4.3. Summary: Designing a Multisensory Ecology of Silent Resonance

The final prototype, *Silent Resonance*, embodied a shift from dyadic interaction to decentralized, sensory-based collective attunement. Through progressive removal of verbal and visual modalities, it invited participants to co-regulate through tactile, olfactory, and spatial cues—mirroring how trees in a forest share information and synchronize states.

This multisensory communication ecology served not only as a speculative design experiment, but also as the foundation for the subsequent user study. The following sections evaluate how participants engaged with this prototype—both in terms of perceptual resonance and internal transformation.

4.4. Study Context and Setup

Seven participants were recruited from the Keio Media Design (KMD) community, selected for their introverted tendencies and diversity of prior experience with multisensory installations. Demographics and responses were recorded through a post-experience questionnaire (see Appendix B).

The prototype was installed in a darkened space. Participants wore eye masks and navigated intuitively using nonverbal cues: airflow, light pulses, ambient sound, and bursts of botanical scent. Each interaction was designed to simulate forest-root communication — decentralized, silent, and sensorially entangled.

4.5. Quantitative Findings

Participants rated seven statements on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Results indicate strong resonance with the system's intended experiential qualities:

Table 4.1 Participant Responses to the Silent Resonance Experience

Statement	**Avg. Rating**
I felt like I became a tree during the experience	4.7
I was aware of others without seeing or speaking	4.5
The system felt decentralized and collective	4.3
Sensory feedback (light, scent, etc.) helped me feel connected	4.3
I understood the rules of interaction clearly	3.8
I discovered new ways of sensing or communicating with others	4.5
The experience was meaningful or thought-provoking	4.7

4.6. Phenomenological Unfolding of Experience

While several participants reported "feeling like a tree," phenomenological analysis reveals this was not an instant reaction but an emergent process that unfolded

through a sequence of embodied experiences. This section maps that transformation by examining the temporal and sensorial phases participants described.

4.6.1 Phase 1: Suspension and Entry

Upon entering the space, participants were guided into darkness and silence. Eye masks and the absence of verbal cues created an intentional "social void," a liminal space between self and other. One participant described this as:

> "I couldn't see or hear anything specific. It was just quiet. I was still me—but I was waiting for something."

This moment of **still anticipation** allowed participants to detach from habitual interaction modes.

4.6.2 Phase 2: Rooting and Stillness

With ambient sound and airflow emerging gradually, most participants slowed their movements and grounded their posture. Several extended their arms outward or downward, unconsciously mimicking the form of a tree.

> "I didn't want to move. I felt like standing still was the right thing to do."
> "My feet became heavy. I stopped thinking."

At this stage, participants described a **downward bodily energy**, like sinking into the ground — metaphorically "rooting" themselves.

4.6.3 Phase 3: Distributed Awareness and Sensory Tuning

As airflow shifted and light pulses began, participants sensed each other's presence through **nonvisual, multisensory gradients**. Several described an emerging awareness of proximity, without movement or sound.

> "I felt someone across from me even though I didn't hear anything."
> "There was a moment when scent came, and I knew something had happened—not near me, but I could sense it."

This reflects a transition to **distributed ecological awareness**, similar to the inter-root signaling metaphor the project aims to evoke.

4.6.4 Phase 4: Becoming a Tree

Only after stillness, tuning, and multisensory feedback did participants describe truly feeling like a tree — not metaphorically, but **viscerally**.

> "It wasn't just stillness. I was connected to something."
> "I didn't have to move to interact. I just was."

This fourth stage marks the culmination of sensory layering into **a felt state of silent resonance**, where boundaries between self, space, and others began to dissolve.

4.6.5 Interpretation

The temporal and sensorial trajectory — from entry void to rooted stillness to silent entanglement — illustrates the core insight of Silent Resonance. It is not merely an installation; it is a designed transformation of presence. This progressive unfolding aligns closely with phenomenological research goals, providing a replicable framework for designing more-than-human, multisensory experiences of attunement.

4.7. Flow and Immersion Analysis

Csikszentmihalyi's Flow theory describes a mental state of deep absorption where individuals lose track of time and self-consciousness while engaging in intrinsically motivating activity. Several participants in this study exhibited markers of such a state, suggesting that the Silent Resonance installation facilitated a unique kind of immersive engagement.

> "I lost track of time. I was just... present."
> "I didn't want to break the silence. It was peaceful."
> "When the scent came, I stopped and tuned in completely."

These quotes reveal a temporary suspension of ordinary perception. Rather than responding to explicit stimuli, participants tuned into subtle, ambient cues. The silence and absence of verbal or visual input paradoxically intensified attention, allowing participants to become immersed in otherwise overlooked senses — airflow, scent, warmth, and proximity.

The experience avoided goal-directed behavior — a typical condition for flow — and instead fostered *attentional openness*, a form of embodied mindfulness. This aligns with recent expansions of flow theory that include contemplative, low-action states (Nakamura & Csikszentmihalyi, 2014), particularly in non-verbal, aesthetic contexts.

Design-wise, this shows that interaction systems do not require feedback-rich, fast-paced engagement to produce immersion. Instead, slow, quiet, and passive systems — when well designed — can lead to deep attentional states aligned with silent ecological metaphors.

4.8. Qualitative Reflections

Open-ended responses from participants offered deep insight into how they physically and perceptually shifted during the experience. The feedback, captured in the second page of the questionnaire (see Appendix B), revealed three dominant experiential motifs: bodily transformation, ecological sensing, and non-hierarchical communication.

4.8.1 Embodied Transformation

Multiple participants described "feeling like a tree," not metaphorically, but through specific bodily changes: standing still, lowering their center of gravity, or extending arms like branches.

> "I found myself grounding my heels and opening my arms, as if stretching into the space."
> "My breathing slowed down. I felt rooted."

This transformation reveals how the installation's design bypassed symbolic representations of trees and activated direct somatic engagement. The sensory

field created by airflow, scent, and ambient sound allowed participants to *embody* the metaphor, not just imagine it.

4.8.2 Awareness Without Visibility

The absence of vision heightened awareness through other modalities. Participants spoke of "feeling" the presence of others without direct cues.

> "I couldn't see anyone, but I knew someone was across from me."
> "The air shifted. I knew something had happened."

This supports theories in ecological psychology (Gibson, 1979) that perception is not limited to active seeing but distributed across dynamic bodily affordances. The participants' sensing resembled animal or plant communication—spatial, gradient-based, and nonverbal.

4.8.3 Decentralized Co-presence

A final theme was the absence of leadership or explicit coordination. Participants reported that no one "controlled" the interaction. Rather, collective movement and stillness arose spontaneously.

> "We were just together. No one was leading."
> "When one person stopped, we all kind of did."

This reflects a shared, emergent rhythm akin to mycorrhizal networks in forests—decentralized but co-regulated. It further reinforces the ecological metaphor: the system's interaction logic is not linear or goal-oriented but resonant and ambient.

4.9. Scent as Silent Signal

Among all sensory layers deployed in the system, scent emerged as the most surprising and affective cue. Unlike sound or light, which carry spatial or rhythmic information, the scent was ephemeral and non-directional — yet strongly recognized as meaningful.

> "The scent was like a quiet message — something happened."
> "I could feel someone had touched someone else. It brought me into stillness."

This suggests that scent functioned as a form of "affective resonance" — not signaling who or where something happened, but simply that something occurred. Participants treated scent as an index of social presence, filling the gap left by missing verbal or visual contact.

Moreover, the asymmetry in timing — the fact that the scent arrived slightly delayed after physical contact — introduced a layer of temporal decentering. The system encouraged not direct response but reflective stillness, unlike traditional interaction designs that demand instant feedback.

In the context of more-than-human design, scent mirrors ecological signaling: in plant communication, chemical release often signals danger or change across species boundaries. Here, it invites participants to pause, attune, and sense others invisibly — amplifying the system's nonverbal ethos.

4.10. Internal and Behavioral Shifts

Despite the brief duration of the installation, several participants described lasting internal effects that extended beyond the interaction. These shifts appeared across emotional, cognitive, and bodily dimensions.

> "I felt unusually calm, even afterward."
> "It was strange — I didn't need to talk to feel connected."
> "I moved less. I noticed more."

These statements suggest a recalibration of social perception. Participants reported sensing others not through action or dialogue, but through ambient cues — smell, warmth, stillness. This aligns with theories of ambient sociality, where connection is formed through co-presence rather than explicit exchange.

The installation also activated qualities often marginalized in design discourse: stillness, silence, introversion. Rather than treating introversion as a social limitation, this system leverages it as a resource — a pathway toward heightened perception and ecological empathy.

While no longitudinal data was gathered, the presence of calmness, nonverbal cohesion, and deceleration suggests that multisensory resonance can softly rewire how individuals perceive and relate to others — especially in silent environments.

4.11. Broader Reflections and Interpretations

This project intersects with a growing body of work in Human-Computer Interaction (HCI) that moves beyond anthropocentric models. The field of more-than-human design seeks to include plants, ecosystems, and nonverbal life forms into the design process — not merely as metaphors, but as epistemological partners.

- **Giaccardi et al.** [11] propose design methods centered on ecological entanglement, where interaction is ambient, slow, and affective. Silent Resonance echoes this, using silence and scent to create "ambient co-presence."
- **Homewood et al.** [12] map bodies as decentralized sensing entities — rather than central controllers. In Silent Resonance, participants became passive nodes in a network of invisible cues.
- **Jewitt et al.** [5] and **Steer et al.** [13] call for interaction systems that do not replicate human communication. This work answers that call by discarding speech, gaze, and gesture, relying instead on multisensory resonance.

Thus, Silent Resonance does not propose interaction as an input-output process, but as a condition of attunement — a collective mode of "being-with." It is not about what one does, but how one is, in relation to others, through silence, rootedness, and resonance.

This shifts design values from efficiency to ecology, from control to participation, and from communication to co-presence.

Chapter 5
Conclusion

This thesis explored the possibility of multisensory, nonverbal systems for human connection inspired by ecological metaphors—particularly forest-root communication. Through an iterative design process culminating in the *Silent Resonance* prototype, the project proposed an alternative paradigm for interaction: one grounded not in screen-mediated dialogue, but in sensory attunement, ambient stimuli, and collective stillness.

5.1. Key Findings

The study found that participants—particularly those with introverted tendencies—resonated with the system's logic of silence, slow unfolding, and nonverbal collectivity. Rather than rely on speech or explicit signals, users reported heightened awareness of others through scent, airflow, and embodied presence. These responses affirmed that forest metaphors can be more than poetic—they can offer practical guidance for multisensory interface design. What emerged was a form of "sensing-with," where attention, breath, and bodily stillness became tools of connection.

Notably, these experiences unfolded progressively. Participants described an initial phase of disorientation, followed by a gradual attunement to subtle cues. By the later stages of the experience, many reported a sensation of being "rooted" or "absorbed into" a larger system—an internal alignment echoing the collective intelligence of forest ecologies.

Importantly, the design achieved more than momentary aesthetic stimulation. Reflections revealed shifts in perception, affective resonance without language, and the emergence of a shared sensorial field. One participant wrote, "I couldn't see

anyone, but I felt their presence—like trees communicating underground." Such feedback underscores that ambient, decentralized interaction can foster shared meaning beyond cognition, and serve as an alternative modality for connection in an overstimulated world.

5.2. Limitations

Despite its contributions, the study bears several limitations. The participant pool, while intentionally selected for their alignment with the design logic, lacked cultural diversity and scale. All participants came from a shared institutional and geographic context, which narrows the interpretive range of the results. Furthermore, the prototype was tested in a short-term and controlled setting, meaning it remains unclear whether its effects could persist or generalize in more complex, real-world scenarios.

No biometric or longitudinal measures were included, making it difficult to assess how deep or lasting the experiential shifts were. Additionally, although participants expressed strong emotional engagement, further tools are needed to triangulate such responses with physiological or behavioral data. These limitations offer important insights for future methodological refinement.

5.3. Future Directions

Future research should expand into more diverse sociocultural settings, exploring how nonverbal resonance manifests across communicative norms. Comparative studies across cultures could help clarify whether certain sensory metaphors—like stillness or scent—carry universal or context-dependent meaning.

Longitudinal experiments would be valuable for observing whether repeated exposure to ambient systems like *Silent Resonance* leads to longer-term changes in empathy, awareness, or nervous system regulation. Integrating biosensors, attention-tracking, or haptic feedback could enhance understanding of how such interactions unfold over time and under varying conditions.

In terms of design iteration, future systems may benefit from subtle onboarding mechanisms. Participants mentioned a need for guidance during initial

moments, suggesting that minimal scaffolding—such as synchronized breathing prompts—could support smoother entry into collective states of resonance without breaking the immersive logic.

5.4. Potential Applications

The project opens doors for a range of potential applications. In therapeutic or clinical settings, the system may offer a nonverbal platform for emotional regulation, particularly suited for neurodivergent individuals or trauma-informed contexts. It could serve as a silent companion tool for mindfulness, group co-regulation, or nervous system decompression.

Public space installations also offer promise. In airports, galleries, or parks, ambient systems like this one could quietly reorient collective awareness toward presence and ecological attunement. Finally, the concept may evolve into new forms of adaptive interfaces—those that respond to stillness, proximity, and affective resonance rather than commands or gestures. Such systems would mark a philosophical shift in human-computer interaction—from controlling machines to coexisting with them.

By reimagining communication as ambient, decentralized, and ecologically attuned, *Silent Resonance* offers more than an artistic experiment—it proposes an alternative paradigm for interaction. In contrast to dominant models centered on speed, visibility, and verbal exchange, this project suggests that meaningful connection may arise through quiet sensing, shared stillness, and bodily presence.

Amid an era marked by overstimulation and constant connectivity, *Silent Resonance* articulates a counter-ethos: one grounded in attunement rather than control, presence rather than productivity. Like the silent intelligence of mycorrhizal networks beneath forest floors, the deepest forms of resonance may unfold slowly, subtly, and outside the bounds of language. In this spirit, the project invites us to imagine new infrastructures of being-together—rooted not in expression, but in shared perception and ecological kinship.

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Appendices

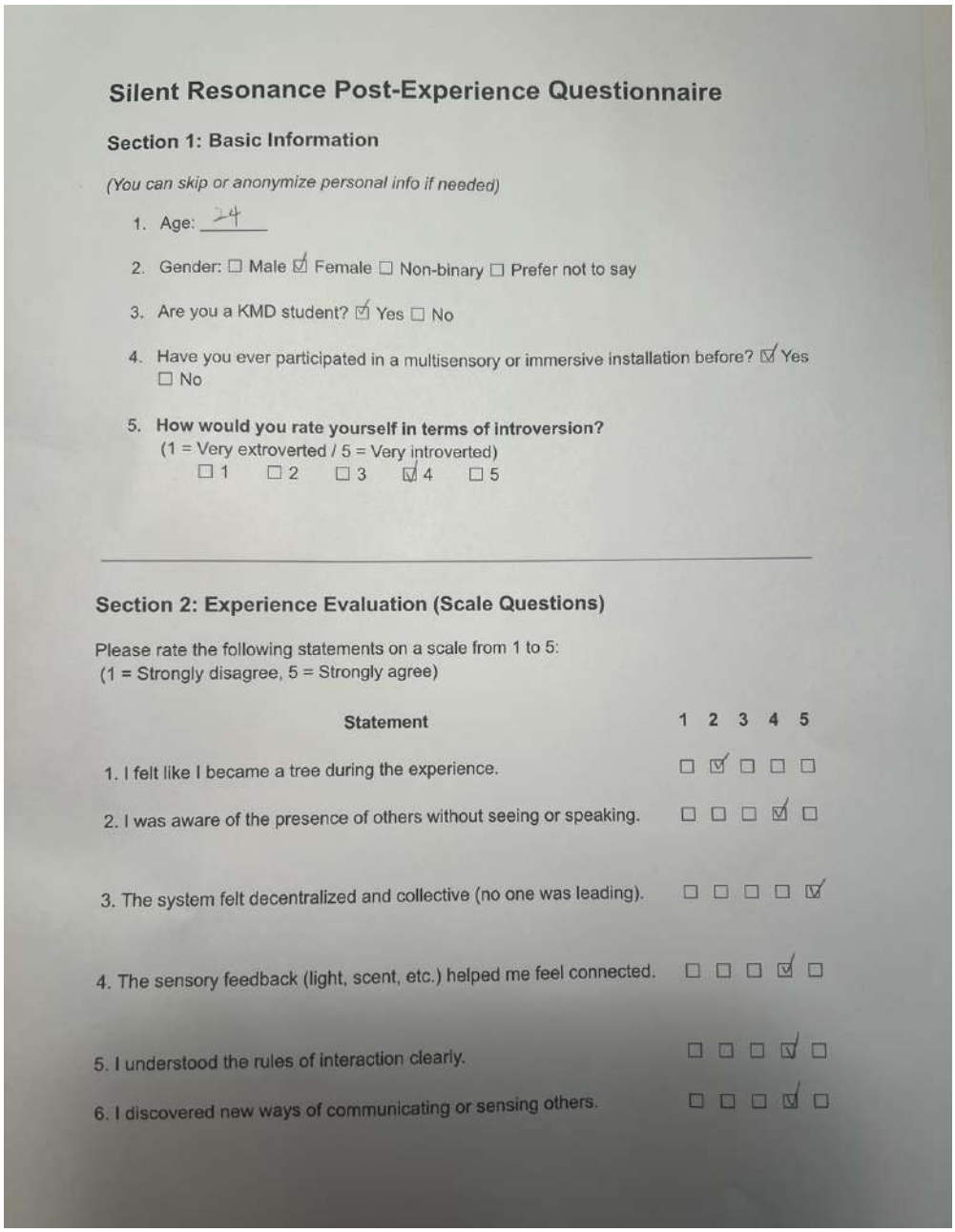
A. Video Documentation

A demonstration video of *Prototype III – Immersive VR Observation of Root Communication* is available at the following link:
`https://drive.google.com/drive/folders/1DGNXz21pKSkvVRdgg7QTc4aaAWIjP7Ar?usp=sharing`

The video captures a participant wearing a Meta Quest 3 headset while standing still and experiencing a VR simulation of underground tree-root communication. The immersive perspective highlights dynamic changes in light, color, and spatial interaction, reflecting the forest's invisible signaling environment. This documentation complements the textual description by illustrating how the prototype was experienced during the KMD Forum 2024 exhibition.

B. Participant Questionnaires

The following responses are from participants who completed the post-experience questionnaire after engaging with the prototype. These documents include both Likert-scale and open-ended answers, reflecting each participant's personal sensory interpretation and emotional engagement during the session.



Silent Resonance Post-Experience Questionnaire

Section 1: Basic Information

(You can skip or anonymize personal info if needed)

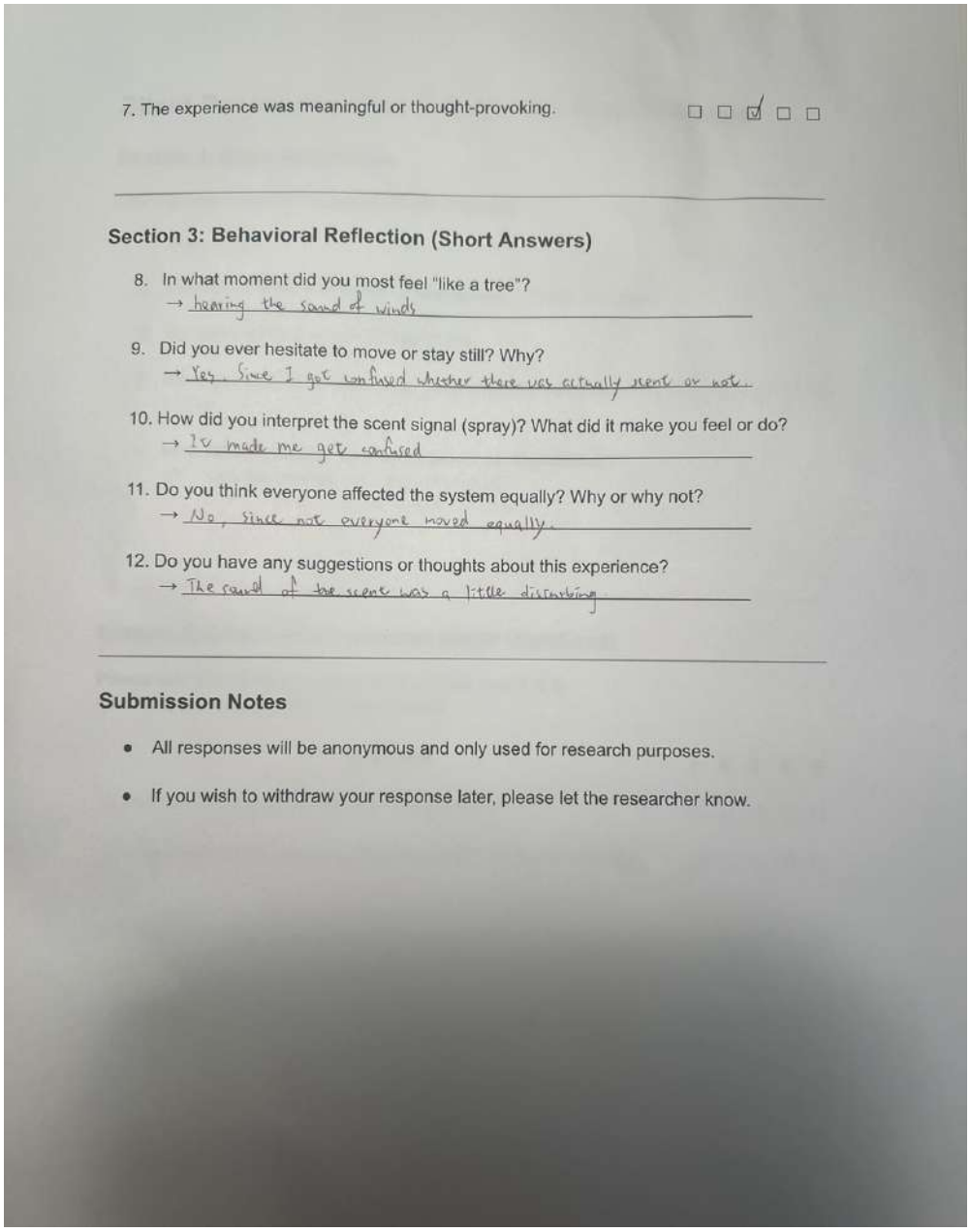
1. Age: 24
2. Gender: ☐ Male ☑ Female ☐ Non-binary ☐ Prefer not to say
3. Are you a KMD student? ☑ Yes ☐ No
4. Have you ever participated in a multisensory or immersive installation before? ☑ Yes ☐ No
5. **How would you rate yourself in terms of introversion?**
   (1 = Very extroverted / 5 = Very introverted)
   ☐ 1 ☐ 2 ☐ 3 ☑ 4 ☐ 5

Section 2: Experience Evaluation (Scale Questions)

Please rate the following statements on a scale from 1 to 5:
(1 = Strongly disagree, 5 = Strongly agree)

Statement	1	2	3	4	5
1. I felt like I became a tree during the experience.	☐	☑	☐	☐	☐
2. I was aware of the presence of others without seeing or speaking.	☐	☐	☐	☑	☐
3. The system felt decentralized and collective (no one was leading).	☐	☐	☐	☐	☑
4. The sensory feedback (light, scent, etc.) helped me feel connected.	☐	☐	☐	☑	☐
5. I understood the rules of interaction clearly.	☐	☐	☐	☑	☐
6. I discovered new ways of communicating or sensing others.	☐	☐	☐	☑	☐

Figure B.1 Participant A – Page 1



7. The experience was meaningful or thought-provoking. ☐ ☐ ☑ ☐ ☐

Section 3: Behavioral Reflection (Short Answers)

8. In what moment did you most feel "like a tree"?
→ hearing the sound of winds

9. Did you ever hesitate to move or stay still? Why?
→ Yes. Since I got confused whether there was actually scent or not.

10. How did you interpret the scent signal (spray)? What did it make you feel or do?
→ It made me get confused

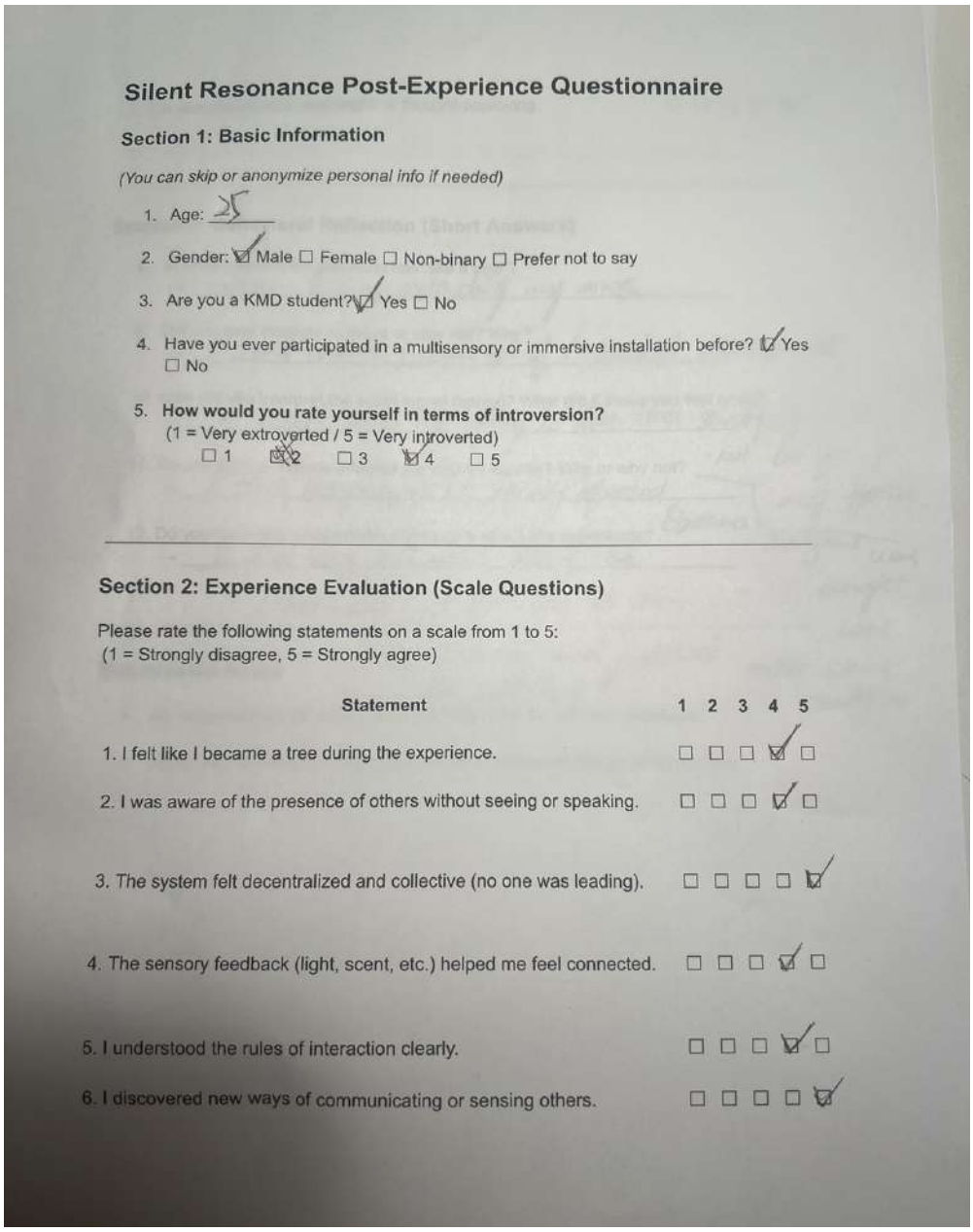
11. Do you think everyone affected the system equally? Why or why not?
→ No, since not everyone moved equally.

12. Do you have any suggestions or thoughts about this experience?
→ The sound of the scene was a little disturbing

Submission Notes

- All responses will be anonymous and only used for research purposes.
- If you wish to withdraw your response later, please let the researcher know.

Figure B.2 Participant A – Page 2



Silent Resonance Post-Experience Questionnaire

Section 1: Basic Information

(You can skip or anonymize personal info if needed)

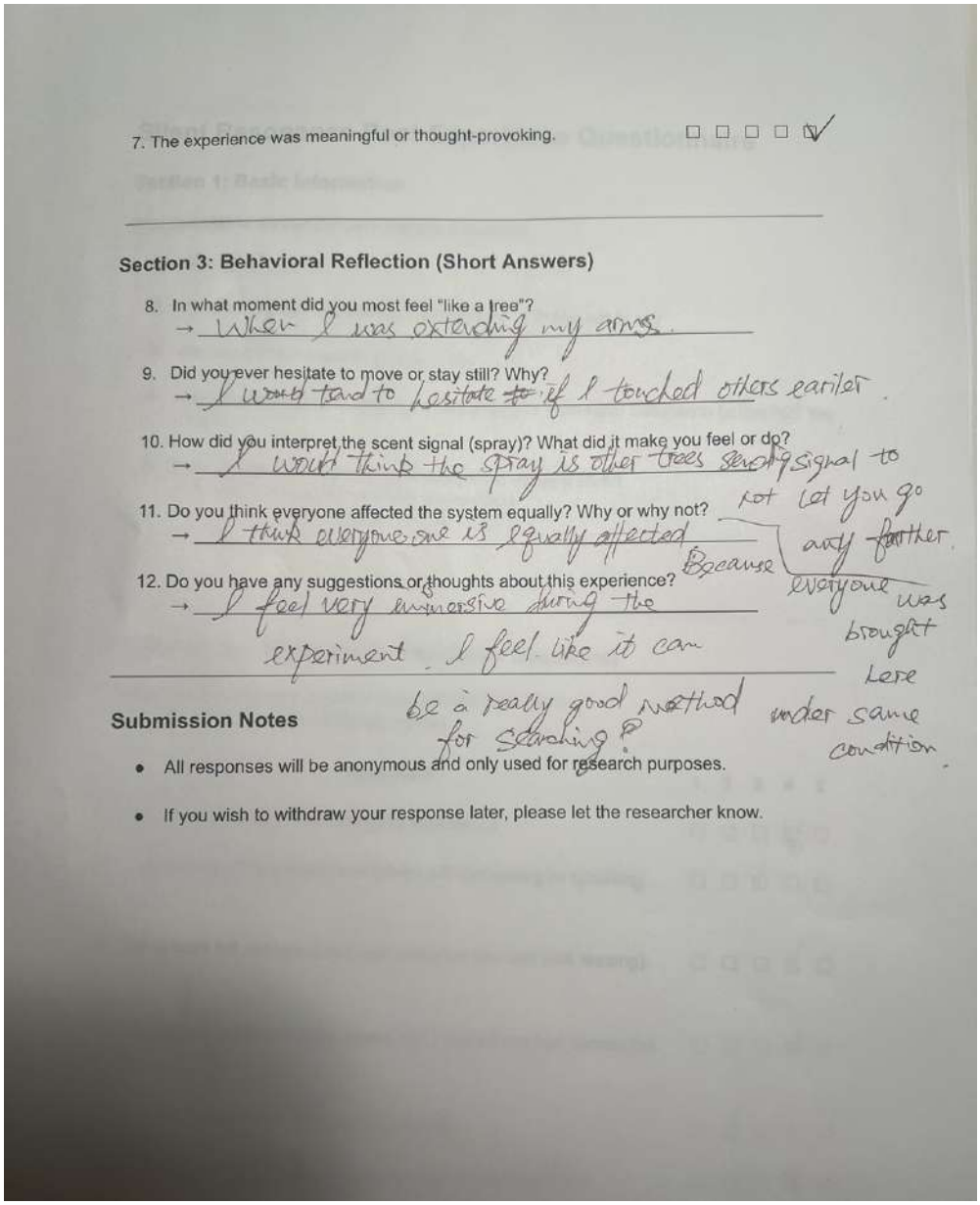
1. Age: 25
2. Gender: ☑ Male ☐ Female ☐ Non-binary ☐ Prefer not to say
3. Are you a KMD student? ☑ Yes ☐ No
4. Have you ever participated in a multisensory or immersive installation before? ☑ Yes ☐ No
5. **How would you rate yourself in terms of introversion?**
   (1 = Very extroverted / 5 = Very introverted)
   ☐ 1 ☒ 2 ☐ 3 ☑ 4 ☐ 5

Section 2: Experience Evaluation (Scale Questions)

Please rate the following statements on a scale from 1 to 5:
(1 = Strongly disagree, 5 = Strongly agree)

Statement	1	2	3	4	5
1. I felt like I became a tree during the experience.	☐	☐	☐	☑	☐
2. I was aware of the presence of others without seeing or speaking.	☐	☐	☐	☑	☐
3. The system felt decentralized and collective (no one was leading).	☐	☐	☐	☐	☑
4. The sensory feedback (light, scent, etc.) helped me feel connected.	☐	☐	☐	☑	☐
5. I understood the rules of interaction clearly.	☐	☐	☐	☑	☐
6. I discovered new ways of communicating or sensing others.	☐	☐	☐	☐	☑

Figure B.3 Participant B – Page 1



7. The experience was meaningful or thought-provoking. ☐ ☐ ☐ ☐ ☑

Section 3: Behavioral Reflection (Short Answers)

8. In what moment did you most feel "like a tree"?
→ When I was extending my arms.

9. Did you ever hesitate to move or stay still? Why?
→ I would tend to hesitate ~~to~~ if I touched others earlier.

10. How did you interpret the scent signal (spray)? What did it make you feel or do?
→ I would think the spray is other trees sending signal to not let you go any further.

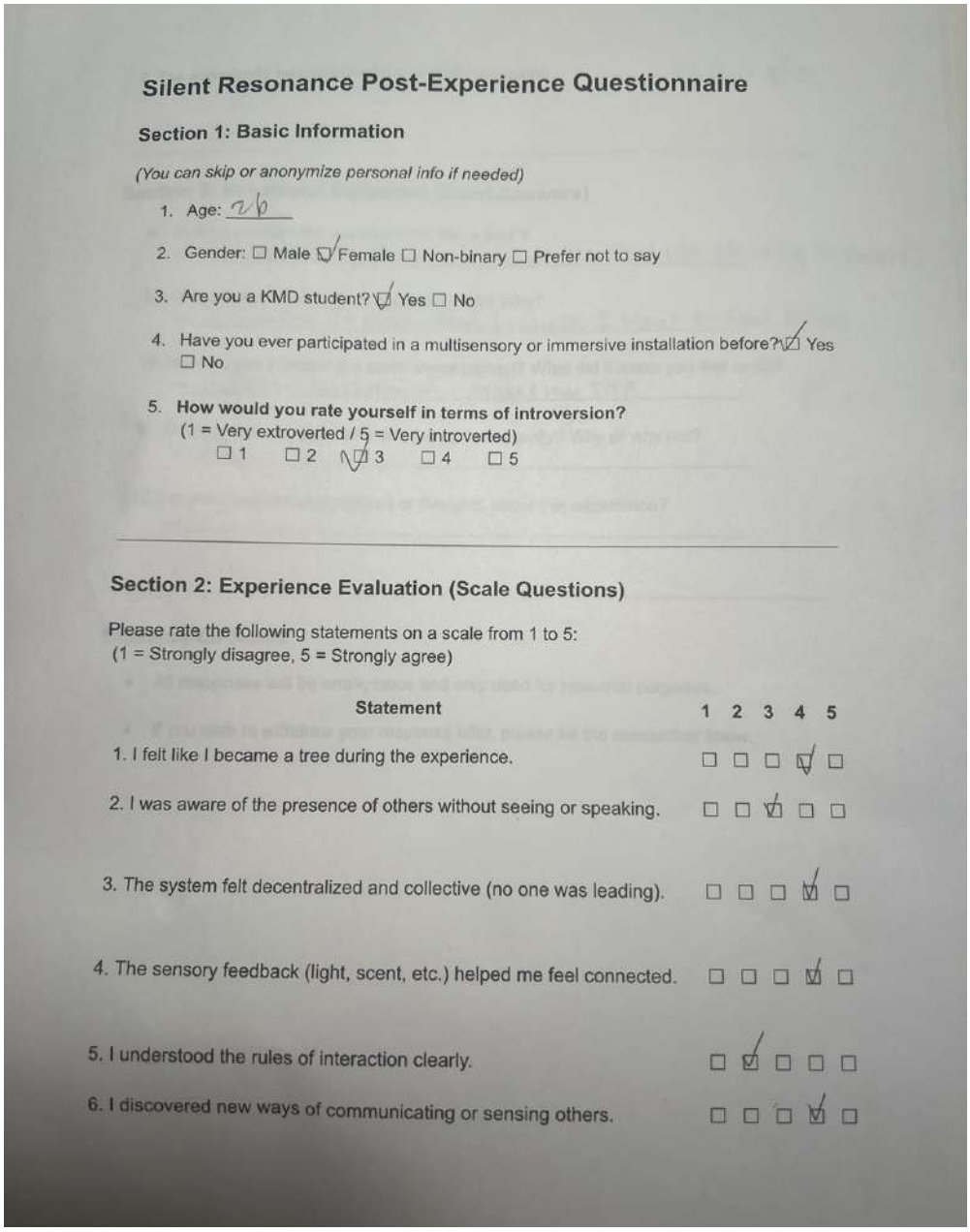
11. Do you think everyone affected the system equally? Why or why not?
→ I think everyone one is equally affected because everyone was brought here under same condition.

12. Do you have any suggestions or thoughts about this experience?
→ I feel very immersive during the experiment. I feel like it can be a really good method for searching?

Submission Notes

- All responses will be anonymous and only used for research purposes.
- If you wish to withdraw your response later, please let the researcher know.

Figure B.4 Participant B – Page 2



Silent Resonance Post-Experience Questionnaire

Section 1: Basic Information

(You can skip or anonymize personal info if needed)

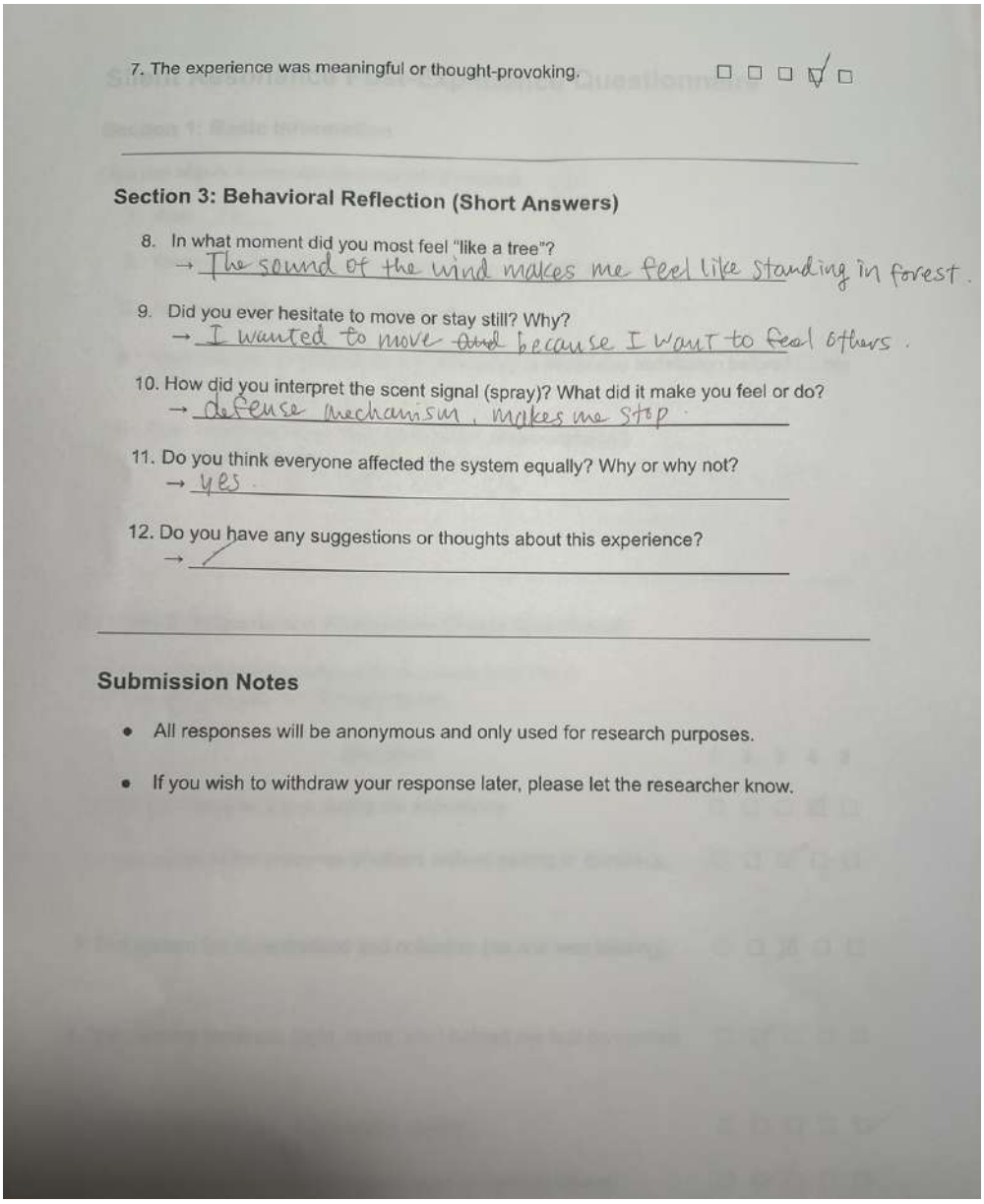
1. Age: n/a
2. Gender: ☐ Male ☑ Female ☐ Non-binary ☐ Prefer not to say
3. Are you a KMD student? ☑ Yes ☐ No
4. Have you ever participated in a multisensory or immersive installation before? ☑ Yes ☐ No
5. **How would you rate yourself in terms of introversion?**
   (1 = Very extroverted / 5 = Very introverted)
   ☐ 1 ☐ 2 ☑ 3 ☐ 4 ☐ 5

Section 2: Experience Evaluation (Scale Questions)

Please rate the following statements on a scale from 1 to 5:
(1 = Strongly disagree, 5 = Strongly agree)

Statement	1	2	3	4	5
1. I felt like I became a tree during the experience.	☐	☐	☐	☑	☐
2. I was aware of the presence of others without seeing or speaking.	☐	☐	☑	☐	☐
3. The system felt decentralized and collective (no one was leading).	☐	☐	☐	☑	☐
4. The sensory feedback (light, scent, etc.) helped me feel connected.	☐	☐	☐	☑	☐
5. I understood the rules of interaction clearly.	☐	☑	☐	☐	☐
6. I discovered new ways of communicating or sensing others.	☐	☐	☐	☑	☐

Figure B.5 Participant C – Page 1



7. The experience was meaningful or thought-provoking. ☐ ☐ ☐ ☑ ☐

Section 3: Behavioral Reflection (Short Answers)

8. In what moment did you most feel "like a tree"?
→ The sound of the wind makes me feel like standing in forest.

9. Did you ever hesitate to move or stay still? Why?
→ I wanted to move ~~and~~ because I want to feel others.

10. How did you interpret the scent signal (spray)? What did it make you feel or do?
→ defense mechanism, makes me stop.

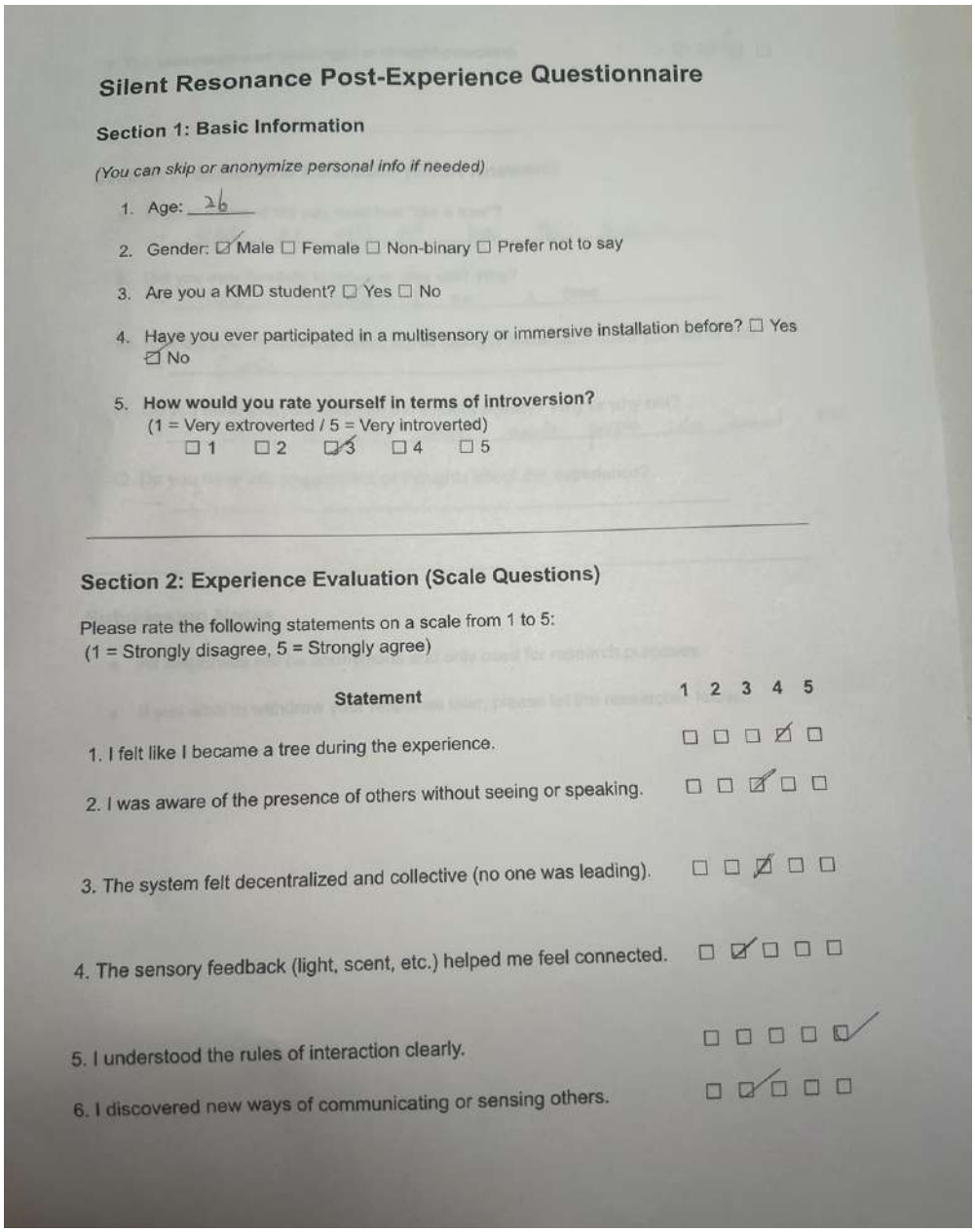
11. Do you think everyone affected the system equally? Why or why not?
→ yes.

12. Do you have any suggestions or thoughts about this experience?
→

Submission Notes

- All responses will be anonymous and only used for research purposes.
- If you wish to withdraw your response later, please let the researcher know.

Figure B.6 Participant C – Page 2



Silent Resonance Post-Experience Questionnaire

Section 1: Basic Information

(You can skip or anonymize personal info if needed)

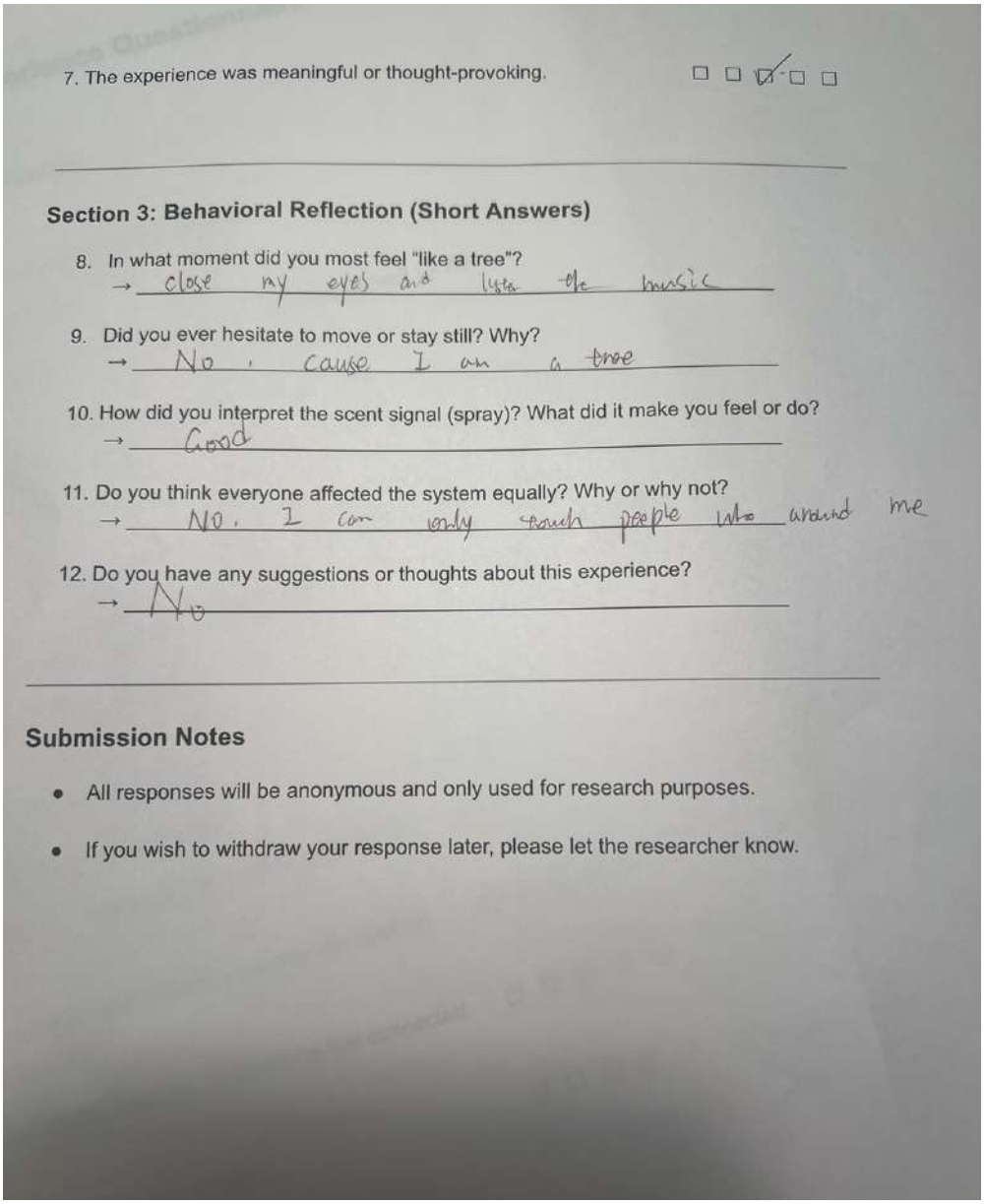
1. Age: 26
2. Gender: ☑ Male ☐ Female ☐ Non-binary ☐ Prefer not to say
3. Are you a KMD student? ☐ Yes ☐ No
4. Have you ever participated in a multisensory or immersive installation before? ☐ Yes ☑ No
5. **How would you rate yourself in terms of introversion?**
   (1 = Very extroverted / 5 = Very introverted)
   ☐ 1 ☐ 2 ☑ 3 ☐ 4 ☐ 5

Section 2: Experience Evaluation (Scale Questions)

Please rate the following statements on a scale from 1 to 5:
(1 = Strongly disagree, 5 = Strongly agree)

Statement	1	2	3	4	5
1. I felt like I became a tree during the experience.	☐	☐	☐	☑	☐
2. I was aware of the presence of others without seeing or speaking.	☐	☐	☑	☐	☐
3. The system felt decentralized and collective (no one was leading).	☐	☐	☑	☐	☐
4. The sensory feedback (light, scent, etc.) helped me feel connected.	☐	☑	☐	☐	☐
5. I understood the rules of interaction clearly.	☐	☐	☐	☐	☑
6. I discovered new ways of communicating or sensing others.	☐	☑	☐	☐	☐

Figure B.7 Participant D – Page 1



7. The experience was meaningful or thought-provoking. ☐ ☐ ☑ ☐ ☐

Section 3: Behavioral Reflection (Short Answers)

8. In what moment did you most feel "like a tree"?
→ close my eyes and lista the music

9. Did you ever hesitate to move or stay still? Why?
→ No, cause I am a tree

10. How did you interpret the scent signal (spray)? What did it make you feel or do?
→ Good

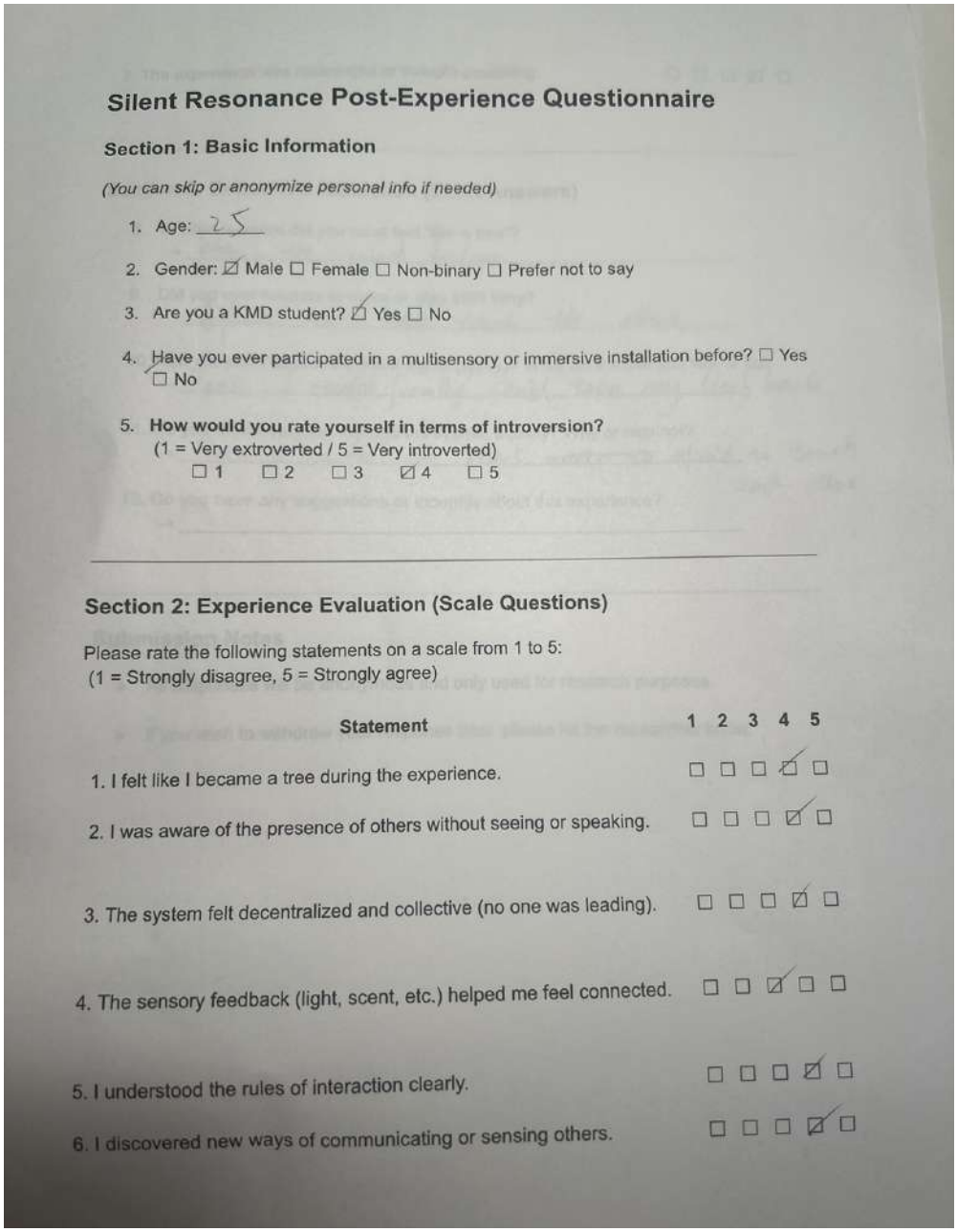
11. Do you think everyone affected the system equally? Why or why not?
→ No, I can only touch people who around me

12. Do you have any suggestions or thoughts about this experience?
→ No

Submission Notes

- All responses will be anonymous and only used for research purposes.
- If you wish to withdraw your response later, please let the researcher know.

Figure B.8 Participant D – Page 2



Silent Resonance Post-Experience Questionnaire

Section 1: Basic Information

(You can skip or anonymize personal info if needed)

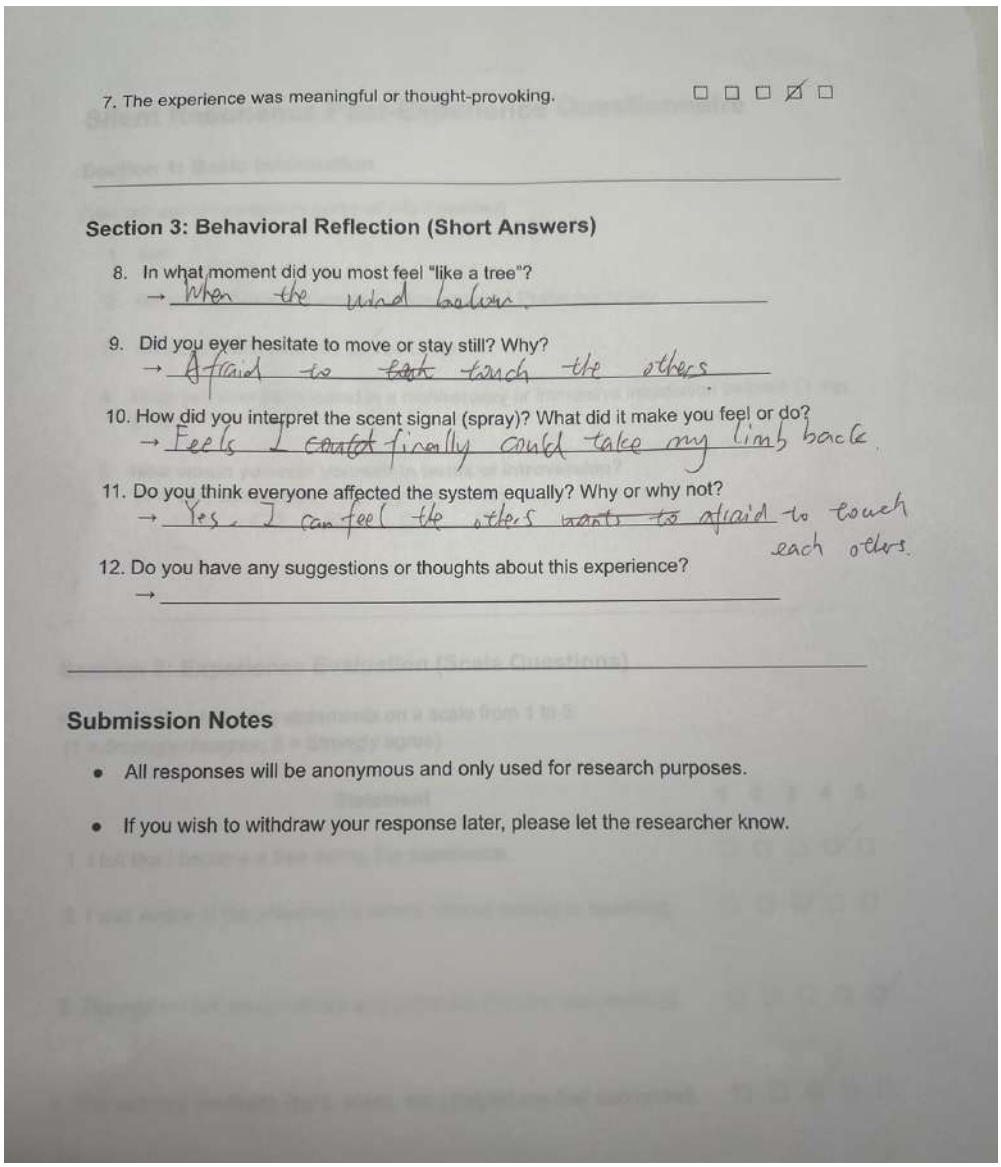
1. Age: 25
2. Gender: ☑ Male ☐ Female ☐ Non-binary ☐ Prefer not to say
3. Are you a KMD student? ☑ Yes ☐ No
4. Have you ever participated in a multisensory or immersive installation before? ☐ Yes ☐ No
5. **How would you rate yourself in terms of introversion?**
   (1 = Very extroverted / 5 = Very introverted)
   ☐ 1 ☐ 2 ☐ 3 ☑ 4 ☐ 5

Section 2: Experience Evaluation (Scale Questions)

Please rate the following statements on a scale from 1 to 5:
(1 = Strongly disagree, 5 = Strongly agree)

Statement	1	2	3	4	5
1. I felt like I became a tree during the experience.	☐	☐	☐	☑	☐
2. I was aware of the presence of others without seeing or speaking.	☐	☐	☐	☑	☐
3. The system felt decentralized and collective (no one was leading).	☐	☐	☐	☑	☐
4. The sensory feedback (light, scent, etc.) helped me feel connected.	☐	☐	☑	☐	☐
5. I understood the rules of interaction clearly.	☐	☐	☐	☑	☐
6. I discovered new ways of communicating or sensing others.	☐	☐	☐	☑	☐

Figure B.9 Participant E – Page 1



7. The experience was meaningful or thought-provoking. ☐ ☐ ☐ ☑ ☐

Section 3: Behavioral Reflection (Short Answers)

8. In what moment did you most feel "like a tree"?
→ When the wind blows.

9. Did you ever hesitate to move or stay still? Why?
→ Afraid to ~~feel~~ touch the others.

10. How did you interpret the scent signal (spray)? What did it make you feel or do?
→ Feels I ~~could~~ finally could take my limb back.

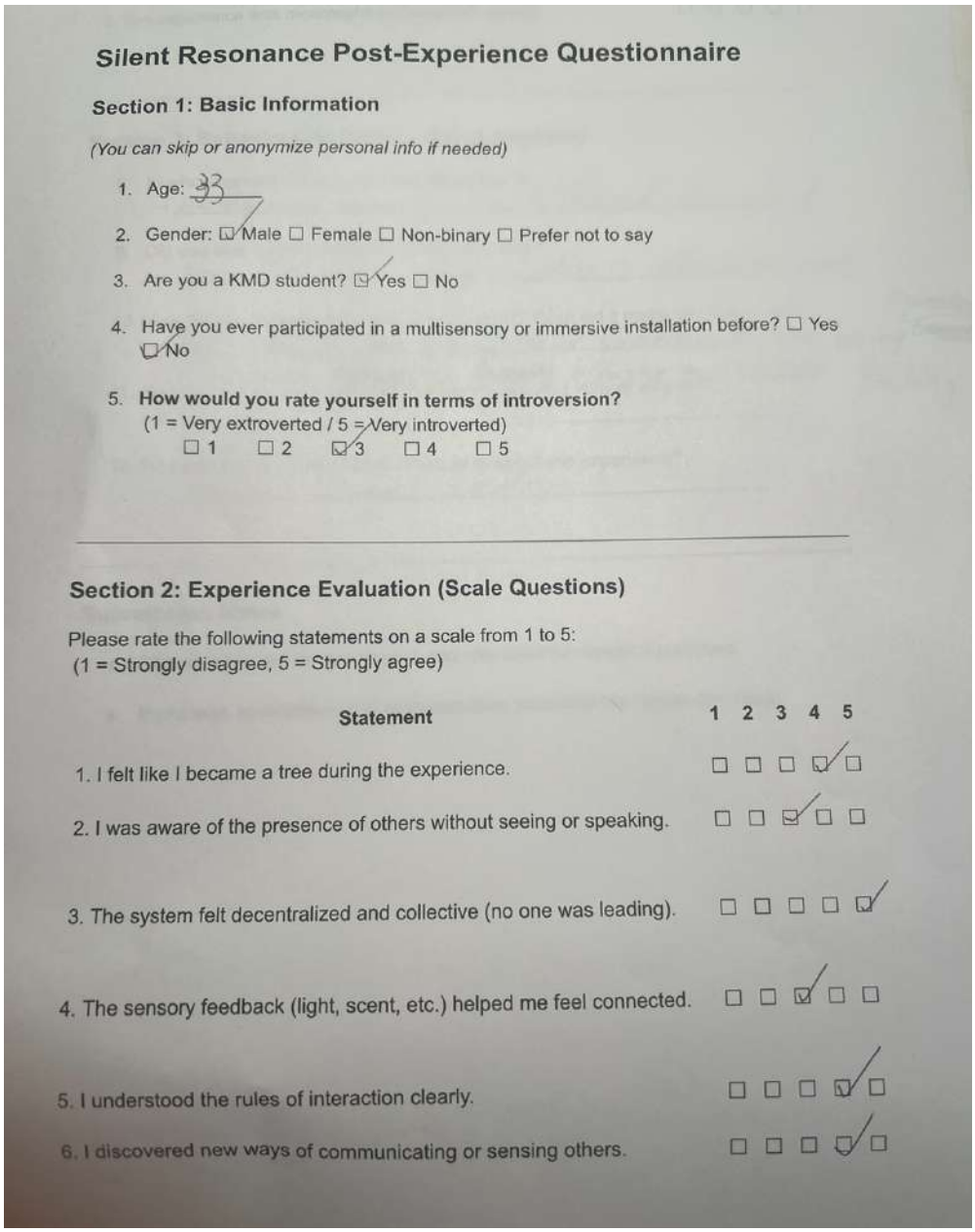
11. Do you think everyone affected the system equally? Why or why not?
→ Yes. I can feel the others ~~wants to~~ afraid to touch each others.

12. Do you have any suggestions or thoughts about this experience?
→

Submission Notes

- All responses will be anonymous and only used for research purposes.
- If you wish to withdraw your response later, please let the researcher know.

Figure B.10 Participant E – Page 2



Silent Resonance Post-Experience Questionnaire

Section 1: Basic Information

(You can skip or anonymize personal info if needed)

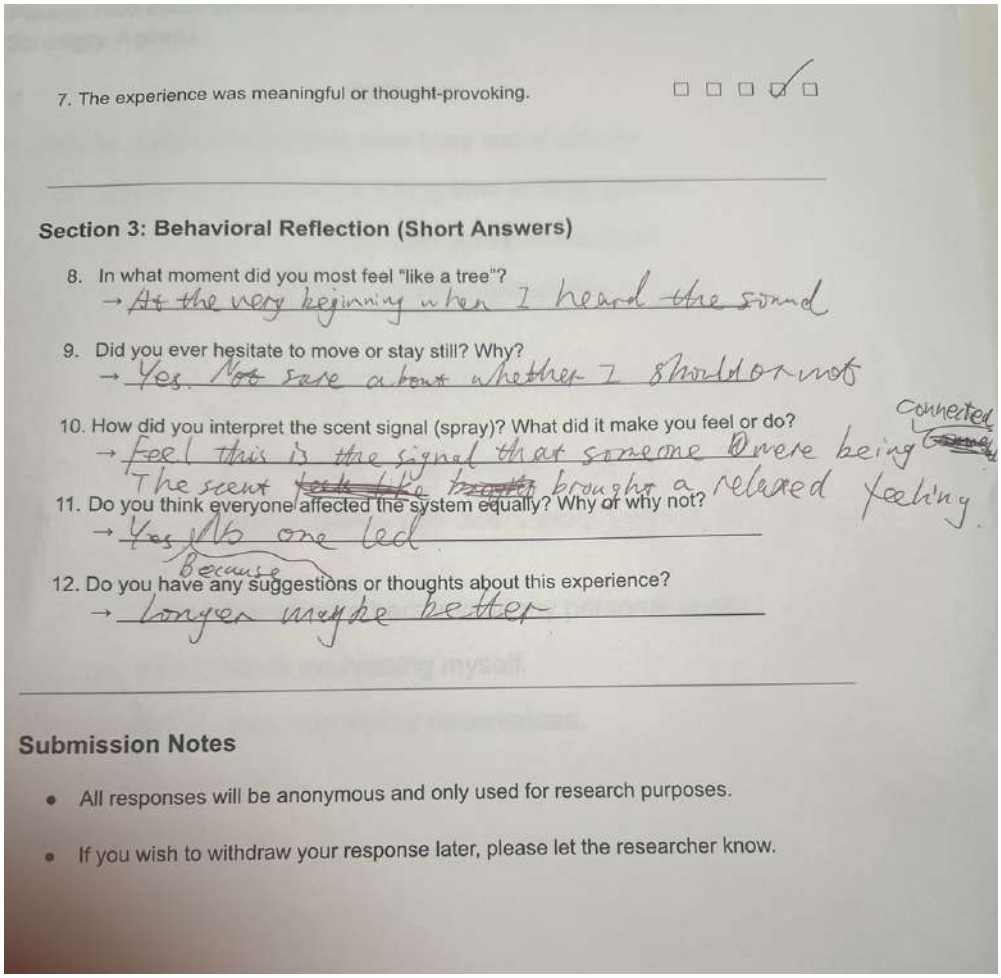
1. Age: 33
2. Gender: ☑ Male ☐ Female ☐ Non-binary ☐ Prefer not to say
3. Are you a KMD student? ☑ Yes ☐ No
4. Have you ever participated in a multisensory or immersive installation before? ☐ Yes ☑ No
5. **How would you rate yourself in terms of introversion?**
   (1 = Very extroverted / 5 = Very introverted)
   ☐ 1 ☐ 2 ☑ 3 ☐ 4 ☐ 5

Section 2: Experience Evaluation (Scale Questions)

Please rate the following statements on a scale from 1 to 5:
(1 = Strongly disagree, 5 = Strongly agree)

Statement	1	2	3	4	5
1. I felt like I became a tree during the experience.	☐	☐	☐	☑	☐
2. I was aware of the presence of others without seeing or speaking.	☐	☐	☑	☐	☐
3. The system felt decentralized and collective (no one was leading).	☐	☐	☐	☐	☑
4. The sensory feedback (light, scent, etc.) helped me feel connected.	☐	☐	☑	☐	☐
5. I understood the rules of interaction clearly.	☐	☐	☐	☑	☐
6. I discovered new ways of communicating or sensing others.	☐	☐	☐	☑	☐

Figure B.11 Participant F – Page 1



7. The experience was meaningful or thought-provoking. ☐ ☐ ☐ ☑ ☐

Section 3: Behavioral Reflection (Short Answers)

8. In what moment did you most feel "like a tree"?
→ At the very beginning when I heard the sound

9. Did you ever hesitate to move or stay still? Why?
→ Yes. Not sure about whether I should or not

10. How did you interpret the scent signal (spray)? What did it make you feel or do?
→ Feel this is the signal that someone Where being connected
The scent ~~feels like~~ brought a relaxed feeling.

11. Do you think everyone affected the system equally? Why or why not?
→ Yes No one lied
Because

12. Do you have any suggestions or thoughts about this experience?
→ longer maybe better

Submission Notes

- All responses will be anonymous and only used for research purposes.
- If you wish to withdraw your response later, please let the researcher know.

Figure B.12 Participant F – Page 2

C. Pre-Test Personality Questionnaire

Participants were asked to rate the following ten statements on a 5-point Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree). The questionnaire was designed to assess introversion, emotional attunement, and sensory sensitivity—key traits aligned with the goals of the *Silent Resonance* prototype.

1. I prefer quiet environments over busy social spaces.
2. I feel drained after spending a long time in large groups.
3. I need alone time to recharge after social interactions.
4. I enjoy observing more than actively participating in group settings.
5. I am sensitive to environmental stimuli such as light, sound, or smell.
6. I often sense how others feel without needing words.
7. I value silent moments shared with others more than casual conversation.
8. I feel uncomfortable when others invade my personal space.
9. I tend to reflect before expressing myself.
10. I find comfort in slow, non-verbal experiences.

D. Post-Test Feedback Questionnaire

The following questionnaire was administered to participants after the immersive prototype session. It was designed to assess sensory awareness, emotional resonance, interpretation of symbolic elements, and reflective feedback.

1. **Part A: Sensory Awareness**
   (a) Which senses did you rely on most during the experience?
   (b) Did you notice the light or scent changes? How did they make you feel?
   (c) Were you aware of others' presence even without seeing them? How?
2. **Part B: Emotional Connection**
   (a) Did you feel any sense of connection or resonance with others?
   (b) Was there a moment when the space felt "alive" or responsive to you?
   (c) How did the blindfold affect your awareness of others?
3. **Part C: Interpretation**
   (a) What did the green light and the scent represent for you?
   (b) Did the experience remind you of nature, trees, or forest systems in any way?
   (c) How did this experience differ from typical group communication?
4. **Part D: Reflection & Suggestions**
   (a) What would you improve or add to the experience?
   (b) Can you imagine other contexts where this kind of non-verbal communication could be meaningful?