Beyond "Seeing"
A Pilot Audio/Tactile Experiment for a Synesthetic Approach to Museum Accessibility

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Abstract
Multiple converging factors are transforming how museums relate to their visitors.
(1) ICOM (2022) introduced an updated museum definition centered on accessibility.
(2) The European Accessibility Act (EAA, 2019/88) recently (June 28, 2025) came into full force.
(3) The Ministry of Culture earmarked PNRR (2022) funds specifically to advance museum accessibility.
Alongside these developments, museum accessibility has drawn growing interest from both scholars and designers. Numerous papers describe cases in which multisensory design facilitates content accessibility (Caruso, 2011; Levent & Leone, 2014; Lupton & Lipps, 2018; Riccò & Hou, 2025; Socrati, 2026). Museums currently find themselves in an unprecedented phase of experiential innovation driven by multisensory experiences. Within this context, a novel tactile experience format was put forward to enrich the possibility of approaching art in a multisensory and engaging way. A pilot experiment was conducted with 24 students at Politecnico di Milano to evaluate and compare tactile perception across various textures under varying visual and audio conditions. User feedback was gathered through administered questionnaires. The experiment results demonstrate that design practices employing synesthetic translations promote communicative accessibility, thereby providing all users with the potential for an expanded experience in accordance with contemporary accessibility regulations.

1. Synesthetic Approach to Museum Accessibility

A convergence of national and international contextual factors is reshaping museums' orientation toward their visitors.

(1) In 2022, the International Council of Museums revised the definition of "museum," introducing the concepts of accessibility, diversity, inclusion, and sustainability. The definition's substantive novelty is encapsulated in the following formulation: "[…] Open to the public, accessible, and inclusive, museums foster diversity and sustainability […]" (ICOM, 2022).

(2) More generally, the European Accessibility Act (EAA, 2019/88), which recently entered into full force on June 28, 2025, requires all digital products and services to be accessible through multiple sensory modalities.

(3) In Italy, the Ministry of Culture has allocated specific PNRR funding to projects that promote museum accessibility, specifically for the "Removal of physical and cognitive barriers in museums, libraries, and archives to enable broader access to and participation in culture" (MiC, Decree No. 534, May 19, 2022). Since 2023, over 1,000 projects have been funded, which should be completed by June 30, 2026, for full access to the heritage. These projects, in compliance with the aforementioned European Directive, offer multiple modes of use, integrated with visual enjoyment, such as tactile itineraries, LIS videos, and audio guides. Consequently, such experiences engage multiple senses beyond vision.

It is this confluence of factors that is catalyzing new design approaches within the national and international scientific com-

munity, in which accessibility is becoming an integral component of museum exhibitions rather than an additional one.

2. Literature Review: Multisensory and Synesthetic Museum

In parallel with the above issues, museum accessibility increasingly attracts scholars and designers. Numerous papers document cases in which multisensory design facilitates content accessibility. Theoretical contributions remain comparatively limited. Available books are predominantly edited volumes of research, design, and exhibition reports. Three volumes merit particular attention:

- *Visioni e oltre (Visions and Beyond)* (Caruso, 2011) comprises the proceedings of a noteworthy conference held in Viterbo, Italy, in 2010, clarifying the relationship between multisensoriality and accessibility. It notably states that "we are still far from a true reflection on the use of multisensoriality in museum displays." In the 15 years since, practices have undoubtedly multiplied; nevertheless, a systematic theoretical treatment remains absent.
- *The Multisensory Museum* (Levent & Leone, 2014) is a fundamental reference because it highlights both the cognitive importance of presenting content across different sensory modalities and the value of making such content accessible to the widest audience.
- *Exhibiting for Multiple Senses* (Fotiadi, 2025) offers a recent overview of curatorial and museum experiences that demonstrate exhibition possibilities grounded in multiple sensory stimuli, with a specific aim to engage people with disabilities.

Among the first books to highlight the close relationship between exhibition spatiality, multisensory experiences, and accessibility potential is *The Senses: Design Beyond Vision*. We share the same objectives and theses as those of this volume in the present contribution. As stated on its back cover, "The Senses is a manifesto for inclusive and multisensory design practices" (Lupton & Lipps, 2018). We fully endorse the main thesis supported by the book's editors: "Sensory design is inclusive. Each person's sensory abilities change over the course of a lifetime. By addressing multiple senses, designers support the diversity of the human condition" (Lupton & Lipps, 2018). Among the most recent contributions, Socrati (2026) presents the approach implemented at the Omero State Tactile Museum in Ancona (Italy), a unique global model for accessibility, as supporting "multisensory for a universal museology".

In Riccò and Hou (2025), we observed that the relationship between the concepts of synesthesia and accessibility is interdependent, and how products (both artistic and design) that can be defined as synesthetic (Anceschi & Riccò, 2000) can, if well designed, similarly be defined as sensorially accessible. Consequently, studying and understanding synesthetic relationships between different sensory languages and their specific perceptual characteristics enables us to design sensorially accessible products. This design process employs translation techniques (Riccò, 2017) when shifting across languages or sensory modes of fruition. Applying a synesthetic approach to museum communication design, therefore, entails not merely ensuring "multiple sensory modalities" but designing the "relationship" between content across dif-

ferent sensory modalities, so that they are coherent and can effectively be considered alternative modalities. Therefore, whether seeing, touching, or hearing a painting, despite the sensory specificities, one should be able to receive equivalent information and sensations. In this context, we understand "synesthetic translation" as a design activity in which generic, spontaneous "multisensory interactions" are directed toward coherent sensory relationships. The museum context is especially suited for investigating these relationships.

3. From "Do Not Touch" to "Touch" Art in Museums

Design practices that enable people with sensory disabilities to access content, culture, and art lead to experimentation with new communication methods and exhibition solutions. These have gradually helped museums break the "do not touch" taboo, benefiting all visitors (Riccò, 2023b).
As Pia Vivarelli (Director of the Galleria d'Arte Moderna in Rome) writes in her introduction to *Les Mains regardent* (1980):

> The "do not touch" of museums remains and will remain an essential condition of a way of understanding the management of cultural heritage, on the one hand, and of enjoying it, on the other, which can only be founded on the shared, profound conviction that the first task of individuals who believe in history is to safeguard the preservation of its documents.

This first exhibition experience was followed by other traveling exhibitions, notably three Italian examples: *Vietato Non*

toccare (Siena, 2004); *Vietato Non toccare* (Milan, 2016); *Toccare la bellezza / Touching beauty* (Ancona, 2019; Rome, 2021) (Riccò, 2023b).

Based on our prior research (Hou & Riccò, 2025), we identify the main tactile experiences that museums currently offer visitors, especially those with visual impairments: original objects, 2.5D reliefs, 3D replicas, tactile maps, tactile drawings/graphics, tactile books, and Braille. However, while these tactile experiences enrich how visitors access information in museums, the range of tactile models available remains quite limited, with "exact replicas" still dominating. Building on this, we aim to better integrate multisensory experiences and synesthesia alongside more participatory tactile activities, helping visitors decipher with greater clarity artwork details. Therefore, we designed three versions of tactile puzzle prototypes and ran pilot experiments to explore the effectiveness of new tactile formats and the role of synesthetic experience in museum accessibility.

4. Pilot Experiments on Tactile-Audio Prototypes

This project was initiated by the SAV Laboratory at the Department of Design of Politecnico di Milano and developed in collaboration with the Virtual Prototyping and Augmented Reality Laboratory led by Professor Mario Covarrubias Rodriguez at the Department of Mechanical Engineering at Politecnico di Milano to create digital-based tactile-audio prototypes. The fresco "Scuola di Atene" by the Italian artist Raffaello Sanzio was selected as our prototypical reference, given that it inspired the logo of Politecnico di Milano.

Owing to the richness of the fresco's narrative, we focused on the group of five figures in the foreground of the lower right corner, which comprises Euclid (or Archimedes) and four students as the subject of our final design. To this end, three tactilization designs were initially developed for the student on the far left of the group (the one wearing a green robe): the basic version, the texture version, and the textile version. These in turn served as control conditions for testing differences in the effectiveness of various tactile forms in information retrieval.

4.1. Prototype Design and Production

Initially, a simplification of the outline was performed (Fig. 1), a crucial step in tactile translation that transforms the complicated shape into a perceivable form. Next, various parts of the figure were divided into sections and converted into 3D models. It is worth noting that when modeling these sections, not all parts were assigned the same height; instead, different heights were designed based on the spatial relationships in the artwork to help users better understand the figure's three-dimensional posture. Subsequently, the assembly design was developed for each module, allowing each puzzle piece to be attached to the base plate. Additionally, the modules were categorized, and texture designs were created for each category.

Upon completion of the 3D models, different versions were 3D-printed. The base plate, once printed, measured approximately 115 mm × 170 mm × 7 mm. For the textile version, an investigation was conducted into Renaissance-era fabrics to identify suitable materials. These fabrics were then cut to size and affixed onto the module surfaces.

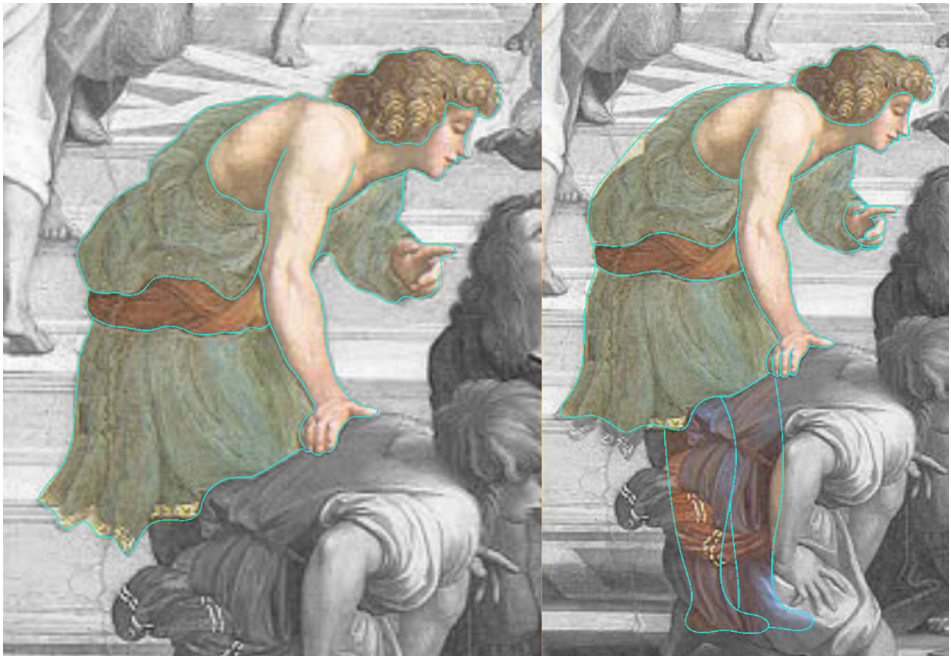

Figure 1. Raffaello Sanzio, Scuola di Atene (1509-1511), a figure in the painting as the source of the tactile prototypes; the detailed version of the outline (left) and simplified version of the outline, created by Weihuan Hou, 2026.

To facilitate puzzle completion and information access, audio guides and audio descriptions were incorporated into the experience, with each prototype version receiving a customized audio guide. As noted by Laura Carlucci, multiple definitions of audio description exist: "a neutral AD for adults, an enriched AD for adults (long and short), an enriched AD for children (long and short), a multisensory AD, and a multilingual AD"/ (Carlucci, 2023).

For this experiment, audio clips were created by ElevenLabs in Italian, featuring a male, clear, deep, and warm voice, with parameters set to a speed of 1, 50% stability, and 60% simi-

larity boost. Presented below are selected excerpts from the audio guide:

> Alla tua sinistra trovi un grande pannello base. Gli altri moduli si trovano nella scatola alla tua destra, pronti per essere presi. Prova ad abbinare i moduli con i diversi tessuti agli incavi corrispondenti sul pannello, seguendone i contorni, in modo da completare l'assemblaggio del personaggio. Ti suggeriamo di considerare che oltre ad abbinare le forme, puoi anche considerare il significato dei diversi tessuti per vestire il personaggio.
>
> On your left, you will find a large base panel. The other pieces are located in the bag on your right, ready to be taken. Try to match the puzzle pieces with their different fabrics to the corresponding cavities on the panel by following their contours, so as to complete the assembly of the character. We suggest that, in addition to matching the shapes, you may also consider the meaning of the different fabrics to dress the character.

4.2. Pilot Experiments with 24 Students

For the experiment, the following materials were prepared: 3D-printed prototypes, eye masks, bags, and QR codes (Fig. 2). To prevent participants from viewing the prototypes in advance and thereby biasing the results, eight opaque bags were prepared, and the pieces were placed inside them.

The experiment involved four main groups, each subdivided into two subgroups (Fig. 3). Through these control groups, tactile formats from different surface treatments were compared for information acquisition.



Figure 2. On the left: Materials for experiments including three versions of tactile prototypes, eye masks, bags, and QR codes, photo by Weihuan Hou, 2026. On the right: Experiment site, photo by Dina Riccò, 2026.

Visual information control tested the effectiveness of synesthetic approaches across all individuals, while Group D contrasted audio descriptions against synesthetic experiences in Groups A, B, and C. Questionnaires with tailored questions gathered user feedback to identify the strengths and weaknesses of each format. The experiment was conducted based on the SAV Lab and as part of the course "Appliances and complex systems design studio" (proff. D. Riccò and G.L. Balzerano, Master of Science degree in Communication Design, Politecnico di Milano).

The test subjects were the 24 students present that day. Before the experiment, a detailed explanation of the upcoming activities was provided, and consent forms were distributed to each student detailing the experimental content and specific procedures. After obtaining the students' signatures and authorization, the experiments commenced. Each group consisted of three students experimenting following the specific steps (Fig. 3).

Groups		Conditions	Task
A Basic Version	Group 1	Blindfolded + Audio Description	**Step 1**: Scan QR Code 1 to Access Audio Guide (To play an audio guide instructing them on what to do and how to do it, while also providing a brief introduction to the textures - for the texture version groups and textile version groups) **Step 2**: Assembly the Puzzle **Step 3**: Scan QR Code 2 to Access Audio Description (To access an audio description, providing further details about the visual characteristics and background information of the prototype they were touching) **Step 4**: Fill out the Questionnaire
	Group 2	Sighted + Audio Description	
B Texture Version	Group 3	Blindfolded + Audio Description	
	Group 4	Sighted + Audio Description	
C Textile Version	Group 5	Blindfolded + Audio Description	
	Group 6	Sighted + Audio Description	
D Without Audio Description	Group 7	Texture Version + Blindfolded	**Step 1**: Assembly the Puzzle **Step 2**: Fill out the Questionnaire
	Group 8	Textile Version + Blindfolded	

Figure 3. Group division with different conditions and tasks.

5. Experiments Results

Ultimately, 23 questionnaires were collected, after which three comparisons were performed on the results.

5.1. A Comparison of Information Acquisition Differences between Blindfolded and Sighted Conditions Under the Same Tactile Version (Group 1 vs Group 2; Group 3 vs Group 4; Group 5 vs Group 6)

As shown in Figure 4, within the same tactile group, no significant difference in information acquisition was observed between blindfolded and sighted groups when perceiving

the model's overall shape and fine details. Notably, within the same tactile model group, some blindfolded participants demonstrated a slightly higher information perception than their sighted counterparts. Upon observation, this difference may be attributed to the degree of immersion in the experience. Because sighted participants could use visual cues to match the puzzle pieces quickly, they completed the task in much less time than the blindfolded group, consequently lacking sufficient immersion to focus on tactile sensations.

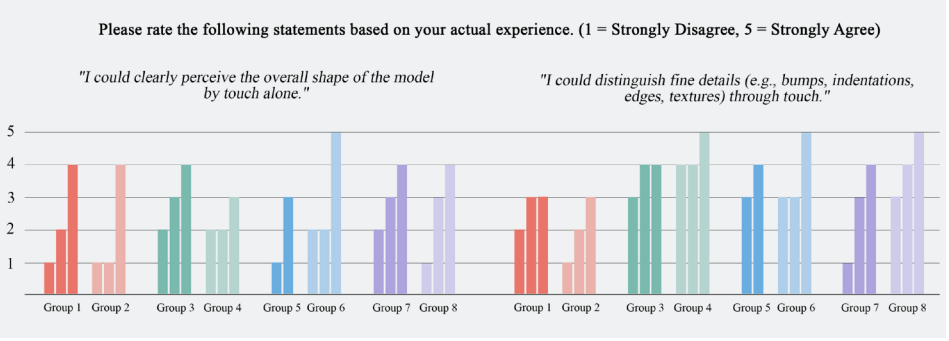

Figure 4. Data 1 of the answers to rate participants' tactile experiences.

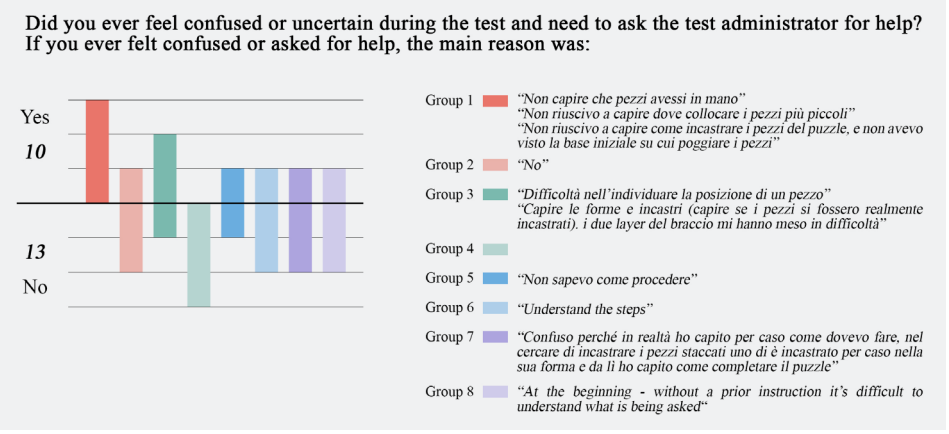

Figure 5. Data 2 of the answers to the question "Did you ever feel confused or uncertain during the test and need to ask the test administrator for help?". Some of the answers in Italian have been translated into English.

Some sighted students reported that, because they could see, the puzzle posed no challenge. However, they found this puzzle format engaging. Consequently, the data (Fig. 5, Fig. 6) clearly show that only two sighted participants felt confused during the activity, and neither required additional guidance. In contrast, 67% of blindfolded students reported confusion, and half of those required additional guidance (Fig. 5, Fig. 6).

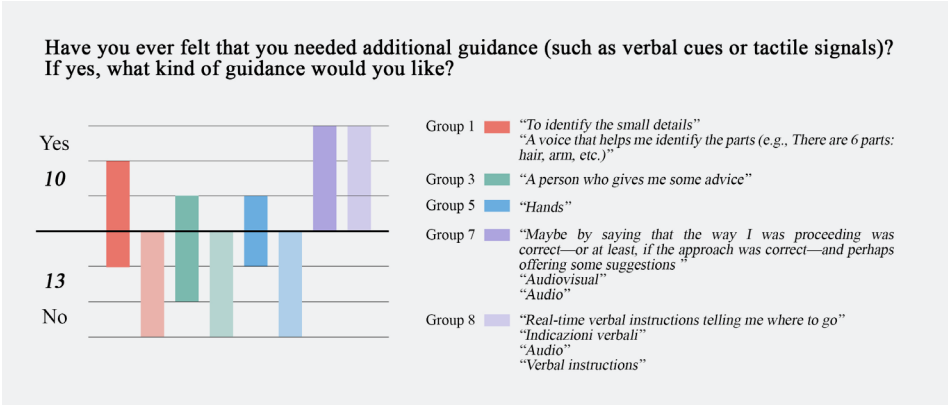

Figure 6. Data 3 of the answers to the question "Have you ever felt that you needed additional guidance (such as verbal cues or tactile signals)?". Some of the answers in Italian have been translated into English.

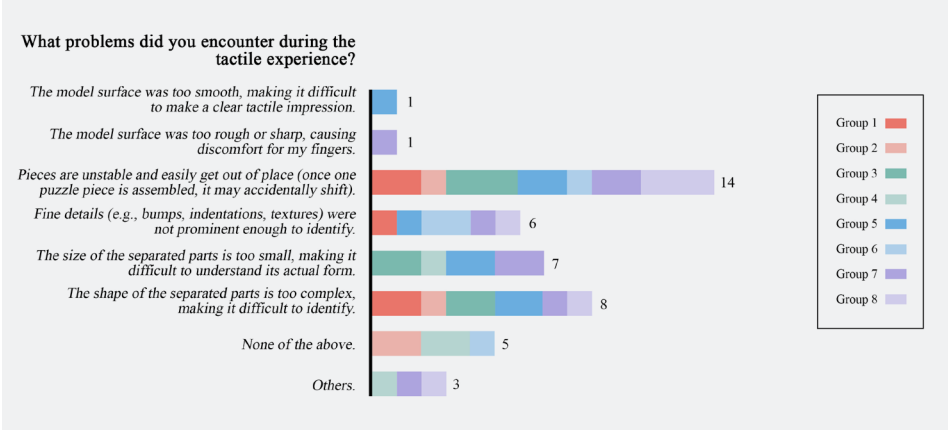

Figure 7. Data 4 of the answers to the question "What problems did you encounter during the tactile experience?".

Overall, participants demonstrated a stronger perception of fine details than of the overall shape. This was primarily due to the excessive complexity of the overall shape, which made it difficult to perceive, and to the fact that some modules were too small for their shape to be discerned (Fig. 7).

5.2. A Comparison of Information Acquisition Differences Across Different Versions of Tactile Experiences Under Identical Visual Condition (Group 1 vs Group 3 vs Group 5; Group 2 vs Group 4 vs Group 6)

Figure 4 reveals that, under blindfolded conditions, the texture version group exhibited superior overall tactile perception, whereas the textile version group performed poorly in perceiving overall shape but excelled in detail perception. Conversely, under sighted conditions, the textile version group showed the strongest overall shape perception, accompanied by a high level of detail awareness. Under sighted conditions, only very limited tactile information was obtainable by students in the basic version group.

Furthermore, under blindfolded conditions, students in the basic version group exhibited a higher propensity for confusion and consequently required additional guidance (Fig. 5, Fig. 6). Therefore, this comparison underscores the importance of tactile differentiation: employing distinct textures and materials enables users to access diverse types of information more effectively and unobstructedly, especially within large and complex information systems.

5.3. A Comparison of the Impact of Audio Descriptions on the Tactile Experience Under Blindfolded Conditions

In the blindfolded group without audio description, all participants expressed a need for additional guidance and showed a preference for audio information (Fig. 6). Interestingly, despite emphasizing the importance of such guidance, this group experienced less confusion during the experiment than did the blindfolded group that was provided with an audio description. A possible explanation lies in two factors related to the audio description itself: its delivery speed being too rapid for participants to follow, and information confusion arising from a lack of synchronisation with the tactile experience. These further highlight the importance of coherence between different sensory inputs in multisensory processes; otherwise, the excess and complexity of information conveyed through multiple senses may create additional barriers. Consequently, synesthesia, as a key strategy for linking information across different sensory channels, emerges as a vital solution to accessibility issues.

Furthermore, when deprived of sight, 64% of participants reported feeling "lost" during exploration, while 43% did not know where to begin touching the model (Fig. 8). Such issues were more likely to arise without audio guides and audio descriptions. Evidently, during tactile exploration, supplementary input from other senses and instructional guidance are crucial for optimizing the experience. In other words, while a multisensory approach broadens the information access channels, the connections between different sensory channels must be considered to avoid sensory overload and information confusion.

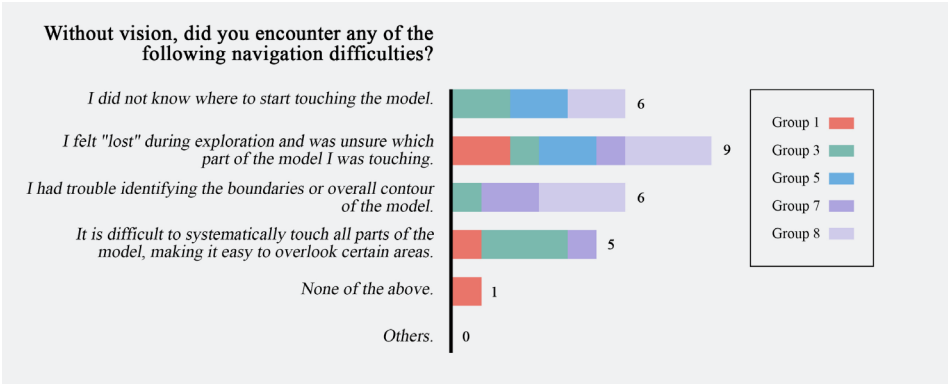

Figure 8. Data 5 of the answers to the question "Without vision, did you encounter any of the following navigation difficulties?".

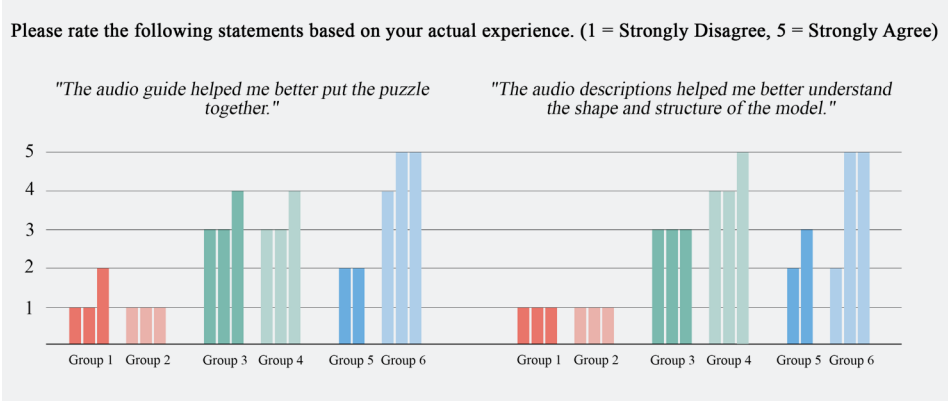

Figure 9. Data 6 of the answers to the rate participants' audio experiences.

5.4. The Effectiveness of Audio Description and Audio Guide

Compared with the basic version group, the texture version and textile version groups exhibited a markedly stronger dependence on audio instructions and descriptions, as documented in Figure 9. That the texture and textile version groups, before starting the puzzle, received audio instructions with detailed accounts of each texture's shape and the associated pieces served to help students construct mental images. In particular,

providing the texture version group with sample panels in addition permitted students to touch the matching patterns while hearing descriptions, a process that created a synesthetic experience. Furthermore, surface tactile contrasts between the two groups (e.g., pattern design variations and material differences) reinforced audio-delivered information, which in turn improved accessibility. Turning to how audio descriptions were integrated, more than half of the participants favored receiving them both before the overall experience and continuously during real-time tactile exploration. A separate 30% selected "real-time description following my touch" as their preference. Therefore, in tactile experiences, neither audio description nor audio guidance can be dispensed with, least of all when forming synesthetic experiences. Sole reliance on audio description carries the risk of disorientation, for instance, if the touched area mismatches the described content. Consequently, with audio guidance, consistency between tactile and auditory inputs tends to be better preserved.

5.5. Overall Assessment

A mean overall satisfaction score of 6.91 (out of 10) was obtained for the experience from the 23 students (Fig. 10). Within the sample, the 'texture version' groups (Group 3, Group 4, and Group 7) yielded the highest overall satisfaction, and their individual scores were notably consistent. For the remaining groups, aggregate satisfaction scores showed no marked differences; however, intra-group individual evaluations diverged sharply. When queried about which aspects were well designed and interesting, the vast majority singled out the texture design as engaging.

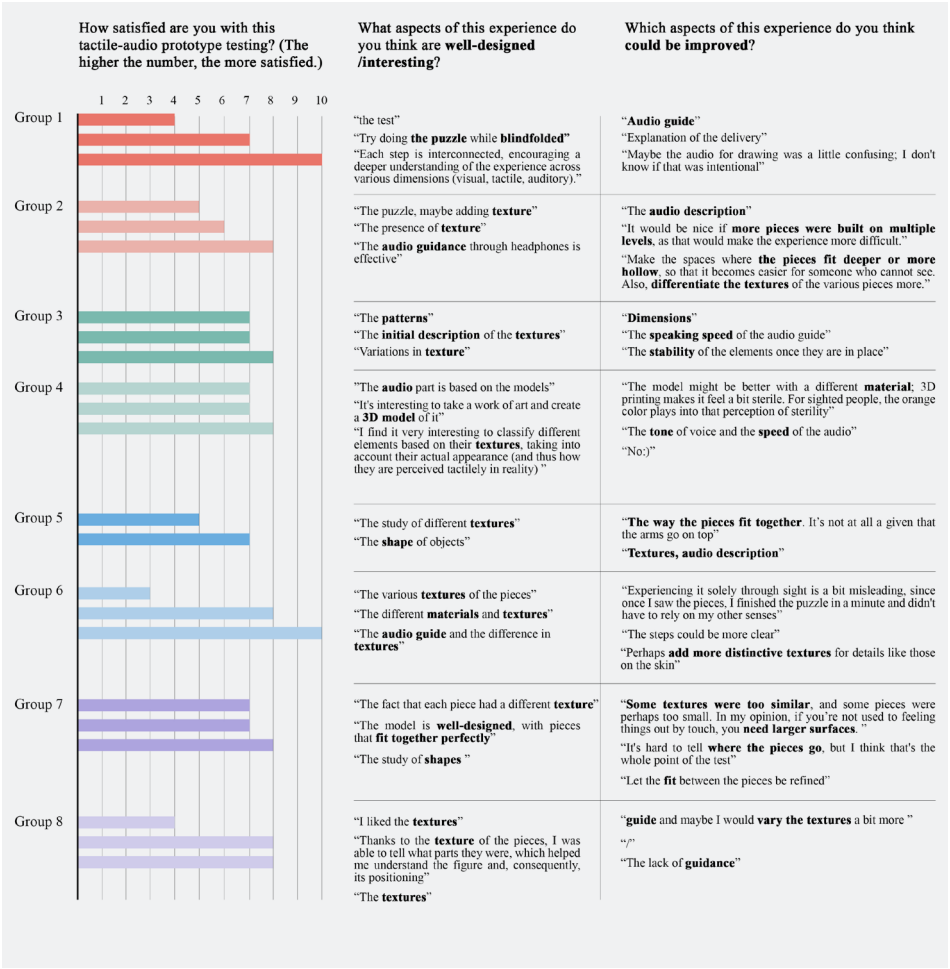

Figure 10. Data 7 of the answers to the overall experiences. Some of the answers in Italian have been translated into English.

Several participants additionally remarked that perceiving art via 3D models constituted an interesting approach. Still others characterized the pre-test audio guidance and texture descriptions as entertaining. With regard to prototype improvements, most feedback centred on the audio parameters, i.e., speaking rate and vocal tone. Other participants pointed to insufficient

stability and fit between modules and base plates, the most frequent issue encountered: "Pieces are unstable and easily get out of place (once one puzzle piece is assembled, it may accidentally shift)." Further input called for introducing more pattern types, along with greater inter-type variation.

To summarise, the experiment first verified that tactile richness and diversity assist information acquisition since tactility is fundamentally an analytical sense that expands the range of perception by sliding the fingers across the surface of an object, thereby constructing a mental image (Tiberti, 2020). A second finding is that multisensory experiences augment this information-absorption capacity. Nonetheless, full accessibility is contingent upon coherence among information across different sensory registers (Riccò & Hou, 2025). Hence, synesthetic design offers a critical route to overcoming accessibility issues. Within museum spaces, where tactile offerings are often uniform, this puzzle-style 3D model, designed with "tactile aesthetics" (Grassini, 2019) in mind, enables further exploration of accessibility via its tactile and audio design, to achieve communicative accessibility across information, cognitive, and sensory levels (Riccò, 2023a).

6. Limitations and Discussions

This pilot experiment does not serve to confirm statistical significance; rather, it aims primarily to refine test protocols and to heighten awareness among sighted individuals and designers regarding the needs of blind persons. Foremost in this activity was the designer's experiential knowledge and capacity for empathizing with the needs of blind individuals.

A secondary objective involved assessing the effectiveness of the novel tactile experience format. Nevertheless, limitations stemming from individual differences and sample size are acknowledged. This pilot experiment was conceived as exploratory in nature, without aiming for absolute or generalizable conclusions. Three experimental rounds involve the additional participation of blind end users. This evaluation was carried out at an early stage, focusing on the tactile-audio prototype rather than providing definitive validation of its accessibility. On the basis of the feedback obtained from this initial pilot experiment, necessary adjustments can be made to chart the direction for the final model.

A further limitation concerns the difficulty of extrapolating findings from healthy, blindfolded participants to actual individuals with sensory impairments. People who are normally sighted, acquired blind, or congenitally blind may each employ diverse multisensory processes. Thus, including blind end users carries substantial significance. In the present pilot experiment, however, some student groups performed the task while blindfolded. Given their lack of prior experience with blindness, these novice participants could offer richer feedback regarding the strengths and weaknesses of the tactile design. Even though this experience primarily targets persons with sensory disabilities, it must remain suitable for all users, tactilely and visually, irrespective of prior exposure. Therefore, blindfolded novice testing does not substitute for testing with blind users; rather, it constitutes an extra validation layer that guarantees universal usability. Future experimental rounds will involve a greater number of blind

and visually impaired participants, thereby increasing the exploratory and practical relevance of this research.

7. Conclusions

Delivering sensorially accessible content to all individuals becomes particularly imperative when that content pertains to artworks, wherein aesthetic and perceptual dimensions are paramount; such delivery demands a project orchestrated across multiple levels. For people with visual disabilities, provisioning content via multiple sensory registers is essential. One must nonetheless emphasize that the possibility of a sensorially expanded and varied experience, that is, not exclusively visual, favors the engagement and comprehensibility of content for all users.

Our experimentation demonstrates that the tactile translation of visual content allows even sighted individuals to attain a deeper grasp of the composition. Such understanding encompasses layered observation, relational analysis, and more profound examination. Simultaneously, this implies defining new spatial relationships between the artwork and the communicative artifacts that facilitate its accessibility. These artifacts are obviously intended not as supplementary additions but as integral constituents of the exhibition design.

Design practices that implement synesthetic translations foster communicative accessibility, thereby affording everyone the possibilities of an expanded experience in line with prevailing accessibility regulations. Therefore, both understanding and more broadly experiencing a museum exhibi-

tion space evidently extends beyond vision, pointing toward projects that engage the full perceptual capacity inherent to visitors.

Acknowledgment

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III

BIOPHILIA IN INTERIOR DESIGN

Multisensory Ecological Attunement

Engaging with the More-than-Human Through Design and Pedagogy

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Abstract
This article explores multisensory design as a practice of ecological attunement, arguing that sensory experience can operate as a critical framework for engaging with more-than-human environments rather than as a decorative layer of space. Drawing on contemporary case studies, the paper identifies four modes of multisensory engagement: Perceiving, Inhabiting, Embodying and Imagining. These modes are then placed in dialogue with a pedagogical context through the RMIT design studio *Downstream: towards an ecological interior*, which used dérive, ecosystem mapping and written field reflections to examine the Royal Society of Victoria as a dynamic system of organic, inorganic, spatial and temporal relations. The studio demonstrates how sensory attention can be translated into spatial propositions through ecological and relational analysis. The paper argues that multisensory ecological attunement offers practical methodologies for developing sensory literacy, supporting students and practitioners to move from static spatial authorship toward responsive, systems-based design.

1. Introduction

Human experience of spaces and places is a multisensory lived experience (Pallasmaa, 2011), in which perception unfolds through connection rather than detached observation. Sensory values are therefore inseparable from social values, with sensory contact functioning as social contact from the outset (Howes, 2019, 2025). Perception is not merely visual or cognitive, but a relational, bodily and ecological way of being in the world, through which values and meanings are perceived directly from the environment (Gibson, 1986/2015).

Within multisensory design, the sensory dimension is often treated as a decorative layer or atmospheric enhancement, frequently organised through visual perception and oculocentric modes of representation. This paper instead understands perception as a relational process operating across inorganic, organic, spatial and temporal domains. Within this framing, multisensory design becomes generative and ecological: a process of attunement to more-than-human environments in which spatial propositions arise through collective, reciprocal and interdependent relations rather than single, self-contained solutions.

Recent work expands multisensory design beyond isolated sensory inputs. Spence (2020) argues for designing for the multisensory mind, while Fradette (2024) extends the designable sensory field to proprioception and vestibular perception. These approaches shift attention from discrete stimuli toward relational and embodied processes of perception.

This shift has particular force in more-than-human design, where environments are not passive backgrounds but active participants in design decisions. Bennett's (2010) account of vibrant matter and Mithal and Gajjar's (2025) description of the built environment as a sentient ruin both suggest that organic and inorganic bodies shape the conditions of coexistence. The task of design, then, is not only to represent these relations but to amplify the sensory and social interactions between humans and nonhumans in shared habitats.

There is also a need to integrate multisensory attentiveness into everyday environments as a fundamental condition of designing for people. Despite increasing recognition of sensory diversity, design practice often relies on assumptions about a typical user and prioritises visual coherence or regulatory compliance over lived experience. As Imrie (2003) argues, this can produce exclusionary spatial conditions in which variability between bodies, perceptions and physiological responses is overlooked (see also Colomina, 1992; Grosz, 1992). Multisensory design therefore shifts from an added layer to a critical framework for engaging with embodied experience through movement, sensation and time rather than abstracted into static visual compositions.

This concern with lived experience extends multisensory design beyond general ecological responsiveness toward care, adaptability and inclusion. Designing from lived and disability experience can reframe spatial priorities around bodily variability and responsiveness (Vermeersch et al., 2018), aligning design with ecological principles of interdependence

and continuous adaptation, where environments are understood as dynamic, evolving systems rather than static, bounded spaces. Accordingly, species do not exist independently of their surroundings but are "tightly woven into the ecosystems in which they live" (Wilson, 1992). Designing through sensory attunement therefore allows spatial environments to respond to shifting conditions such as light, temperature, sound and material change. Meaning in space is continually regenerated through interaction (Baumers & Heylighen, 2010) and through habits of action (Määttänen, 2007), making experience over time central to design. Multisensory design thus recalibrates spatial practice around relational awareness rather than exclusive standardisation, recognising difference, variability and perception as integral to more inclusive and adaptive forms of inhabitation.

Interior design education has likewise favoured visual modes of representation, limiting the development of multisensory approaches (Ebbini, 2026). This misrepresents design knowledge as primarily oculocentric and egocentric, rather than embodied, relational and situated. Many pedagogical approaches still isolate individual senses rather than considering their interaction (Altay, 2017), creating a gap between graduate skillsets and contemporary interior practice, which increasingly seeks to produce relational environments (Almirón Cuentas & Bernedo-Moreira, 2024). A systems approach supports more robust and cross-disciplinary modes of learning.

This paper synthesises work from hybrid research groups at Politecnico di Milano Design Department and RMIT Uni-

versity, School of Architecture and Urban Design, bringing together ecologists, interior designers and life scientists. It investigates the role of multisensory design within more-than-human and cross-disciplinary frameworks, and its integration into higher education. First, contemporary case studies are reviewed to examine projects in which perception, material conditions and environmental interactions co-produce spatial outcomes. The paper then presents the *RMIT studio Downstream: towards an ecological interior*, which extends these principles into a pedagogical context and evaluates their methodological implications, offering insight into how multisensory and ecological thinking can be further integrated into design education.

Methodologically, the paper combines interpretive case-study analysis with pedagogical reflection from the Downstream studio. The case studies were selected for their mobilisation of multisensory experience as a means of engaging with more-than-human actors, rather than treating sensory design as atmosphere, aesthetic effect or isolated stimulus. They were read comparatively through patterns of sensory engagement, spatial relation, embodiment and speculative projection, from which the four modes of Perceiving, Inhabiting, Embodying and Imagining were synthesised. The studio component was evaluated qualitatively through analysis of student field notes, dérive documentation, written field reflections, ecological mapping exercises, critique discussions and final spatial propositions. Rather than treating attunement as a psychophysical variable, the paper examines how sensory attention was documented, interpreted and translated

into design methods. In this sense, attunement is understood as the capacity to notice, describe, map and work with relational conditions across organic, inorganic, spatial and temporal domains.

2. From Estrangement to Engagement: Mapping Multisensory Design Practices for More-than-Human Encounters

"Design, carried forward through information, media, technology, goods and services, has tremendous impact on the way that human activities impact nature, and on how people perceive nature." With these words, Dr. Louise St. Pierre (2019, p. 92) frames a historical account of this relationship, tracing the influence of a mechanistic mindset that has long shaped design through ideas of progress and mastery. Against this trajectory, more recent approaches to designing with nature foreground "humility, understanding and relationship" (St. Pierre, 2019, p. 105), positioning design as a relational practice that engages with ecological systems rather than imposing upon them.

Within this evolving landscape, the more-than-human turn in design (Forlano, 2017; Giaccardi & Redström, 2020; Wakkary, 2021; Nicenboim et al., 2024) has brought renewed attention to the challenges of engaging with nonhuman actors. As De Roo et al. (2025) suggest, these include a persistent sensibility crisis, namely an attenuation of perceptual and affective capacities (Morizot, 2022); a culturally entrenched human–nature divide rooted in Western thought (Stengers, 2007; Vogel, 2011); and the complexity and uncertainty inherent in ecological systems (Tănăsescu, 2025).

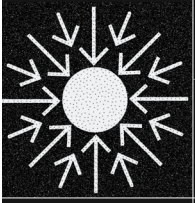
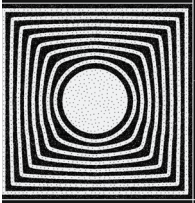
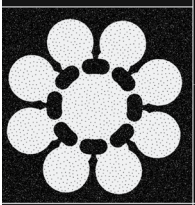
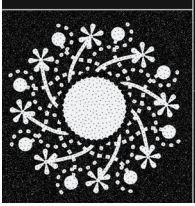
CATEGORY	ACTION	Project	Sensory activations
PERCEIVING 	*MULTI-TUNING* / BEYOND SIGHT	SONIC KINESTHETIC FOREST Tang et al., 2024	• Natural & musical sounds _ hearing • Spontaneous & coreographed exploration _ proprioception + movement
		PSYCHOSOMA Eva Merriel Hurst, 2024	• Natural fragrances _ smell • Water flow _ touch • Light and colour shifts _ vision
	TRANSLATING / SENSORY LANGUAGE	PLANTSLATOR Eros Risiglione, 2023	• Tactile interactions _ touch • Biofeedback-generated sounds _ hearing
		PLANT SENSORIUM Hansen & Rolighed, 2024	• Tactile interactions _ touch • Biofeedback-generated outputs _ vision + sound
INHABITING 	*BREATHING IN* / IMMERSION	AUSTRIA EXPO 2015 Breathe Earth, 2015	• Temperature & Humidity shifts _ touch • Fog diffusion & VOC _ smell • Immersive enclosure _ vision
		AIRSHIP.02-EVAPOTREE Breathe Earth, 2017	• Temperature & Humidity shifts _ touch • Mist diffusion & VOC _ smell • Shielded & redirected sunlight _ vision
	BEING WITH(IN) / COHABITATION	INSIDE THE FLOWER LAVA, 2017	• Contact with organic surfaces _touch • Edible plant extracts _ taste • Immersive enclosure _ vision
		ALUSTA Suomi & Mäkelä, 2024	• Decay-enhancing materials _ vision • Porous & "hospitable" surfaces _ touch • Facilitated plant proliferation _ smell
EMBODYING 	*FEELING* / EMPATHY	ENTANGLED HABITATION Ariaxiying, 2023	• Tactile-somatic coupling _ touch • Biofeedback- mediated movements _ touch
		THE FLORENCE EXPERIMENT Höller & Mancuso, 2018	• Sliding movement _ proprioception + movement • Physical stewardship of plant _ touch • Emotion-generated VOC _ smell
	BECOMING / IDENTIFICATION	PLANT BECOMING PROJECT Bui Adalsteinsson, 2021	• Performative exercises _ propioception + movement • Stillness & environmental exposure _ touch
		POLLINATION EQUIPMENT Ance Janevica, 2019	• Wearable extentions _ touch • Manual engagement with flowers _ smell • Task-based enactment _ proprioception + movement
IMAGINING 	*ACCESSING* / NARRATIONS	TALE OF A TREE HUMAN NonHuman Nonsense, 2020	• Embodied alignment with imprints _ touch • Auditory storytelling _ hearing • Sculptural eyes on trees _ vision
	EXPERIENCING / ALTERNATIVES	MITIGATION OF SHOCK SUperflux, 2017	• Scarce & artificial light _ vision • Compressed living spaces _ proprioception • Elevated humidity _ touch + smell

Figure 1. Lucia Ratti, case study synthesis table, multisensory design practices and more-than-human engagement modes, 2026.

Multisensory design practices offer a response to these conditions by foregrounding relational engagement between human and nonhuman worlds. Drawing on ongoing PhD research into design's role in fostering Plant Awareness (PA), this analysis examines a series of case studies selected for their multisensory engagement with nonhuman actors and their distinct

relational strategies. Cases were identified through purposive sampling across university platforms and major exhibition venues using keywords related to more-than-human design and the dimensions of PA (Dünser et al., 2025), supplemented by snowball sampling. Through thematic analysis, and using De Roo et al.'s three challenges as an organising framework, four modes of engagement emerge: Perceiving, Inhabiting, Embodying, and Imagining. Together, these operate as a gradient of engagement, moving from the activation of attention through spatial immersion and corporeal integration toward speculative projection (detailed in Fig. 1).

2.1. Perceiving: Multi-tuning and Translating More-than-Human Expressions

Perceiving is framed here as a response to the sensibility crisis, seeking to expand how natural environments are registered beyond conventional sensory channels. Perceiving nature in a sentient manner becomes a way of establishing relation, "not with the eye but through correspondences with our surrounding natural and physical worlds" (Segers, 2025, p. 199), operating through sounds, smells, signals, and movement. Projects in this category extend the perceivability of vegetal beings through multituning across sensory channels or by translating plant signals into human-perceivable forms.

Projects such as *Sonic Kinesthetic Forest* (Tang et al., 2024) expand perception through embodied and multisensory practices, combining landscape design and dance to develop "movement vocabularies" around trees in a Canadian forest and explore how "kinesthetic empathy" emerges through

integrative experience. Similarly, *Psychosoma* by Eve Merriel Hurst (2024) engages multiple sensory channels through plant fragrance and ritualised contact with water, inviting reflection on plants' healing properties.

Other projects explore the translation of nonhuman signals into alternative sensory modalities, an approach common within Human-Computer Interaction research (Hansen & Roli-ghed, 2024; Janicki et al., 2024; Wu et al., 2025). While many rely on visual outputs, some adopt cross-modal approaches, such as *Plantslator* by Eros Risiglione (2023), which transforms electrical plant signals into sound patterns, enabling a more immersive and non-visual mode of relation.

2.2. Inhabiting: Breathing in and Being With(in) More-than-Human Atmospheres

Inhabiting is positioned as a response to the human-nature divide, foregrounding the body's continuous porosity to its environment. The spaces we inhabit permeate the organism through breathing and ingestion, establishing physiological, psychological, and cultural connections (Naves & Duarte, 2026). When made explicit, this condition can counter the "delusion of grandeur" that separates humans from other life forms (Margulis, 1998).

Projects in this category use immersion to make ecological processes experientially tangible. The Breathe Earth Collective (n.d.) exemplifies this through microclimatic environments in which photosynthesis and evapotranspiration are encountered through smell, humidity, and touch, creating a direct bodily link between human and atmosphere.

Other projects extend immersion into co-inhabitation, emphasising shared ecological conditions between human and nonhuman actors. Inside the Flower (LAVA, 2017) and the Alusta Research Pavilion (Suomi & Mäkelä, 2024) create inhabitable environments that foreground growth, decay, and seasonal change, positioning visitors within ongoing systems where material transformation, temporal rhythms, and multispecies presence become directly encounterable.

2.3. Embodying: Feeling and Becoming More-than-Human Beings

Embodying moves beyond immersion toward direct relations between human and nonhuman bodies. It frames the body as an interface shaped through multispecies interaction (Coccia, 2022), operating through sensing with the other and becoming the other.

Entangled Habitation (Ariaxiying, 2023) and *The Florence Experiment* by Carsten Höller and Stefano Mancuso (Colón et al., 2019) demonstrate affective coupling between human and plant systems. Wearable devices and experimental setups translate plant signals into sensory feedback, allowing humans to register stress, vitality or reciprocal physiological response through their own bodies.
The Plant Becoming Project (Mannyrkia, n.d.) and *Pollination Equipment* (Janevica, 2019) explore embodiment through role reversal. Participants temporarily inhabit nonhuman perspectives by performing rooting, watering, photosynthesis or pollination, using direct participation to reflect on ecological dependency and multispecies roles.

2.4. Imagining: Accessing and Experiencing Alternative More-than-Human Realities

Imagining responds to ecological complexity and uncertainty by mobilising multisensory engagement within speculative and narrative frameworks. Accepting that ecological systems exceed full comprehension, and that "ignorance is structural" in ecological relations (Tănăsescu, 2025, p. 44), this category positions speculation as a legitimate mode of engaging with the unknown through "thought experiments" (Dunne & Raby, 2014, p. 147) that embrace uncertainty as a condition of possibility.

Tale of a Tree Human (Nonhuman Nonsense, n.d.) invites participants into a mythological narrative through embodied interaction, where contact with a tree trunk provides access to alternative temporalities and perspectives, using sensory engagement to attune participants to nonhuman modes of existence. Other projects construct immersive speculative environments in which participants experience possible ecological futures. *Mitigation of Shock* (Superflux, 2017) presents a domestic interior shaped by ecological crisis, where indoor cultivation redefines human–plant relations, and where spatial constraints, atmospheric conditions, and sensory density produce an embodied understanding of cohabitation as necessity rather than choice.

3. Pedagogical Framework: Spatialising Multisensory Ecologies

This section introduces the design studio *Downstream: towards an ecological interior* as a pedagogical framework for translating multisensory and ecological thinking into interior

design practice. The studio, developed within the RMIT Bachelor of Interior Design and led by interior designer Hannah Moriarty and ecologist Alastair Reed, operates as a site of experimentation, testing how relational and systems-based approaches can be embedded within design processes. Students are introduced to a core premise: spatial conditions emerge through interconnections rather than isolated elements. To operationalise this, they adopt a systems view, extracting and mapping elements across four domains - organic, inorganic, space and time - and identifying interactions between them as the basis of multisensory experience. By emphasising relationships, the studio positions spatial practice as engagement with interconnected processes rather than independent forms.

A key challenge was translating ecological tools into design methods applicable beyond scientific disciplines. The studio therefore developed a functional dialectic linking elements, roles, and affordances. Students identified two elements across the four domains, described the role one element played in relation to the other, and named the affordance produced, establishing a practical definition of interaction. By connecting contiguous interactions into wider relational webs, students began to understand spatial function as emergent rather than as a collection of isolated features. In this sense, elements could be reconsidered as an interchangeable kit of parts, where emphasis shifted from fixed objects toward the interactions and affordances required for particular programs or activities to occur.



Figure 2. Aland Razagho, dérive observations across the four domains, Downstream: towards an ecological interior, RMIT, 2025.

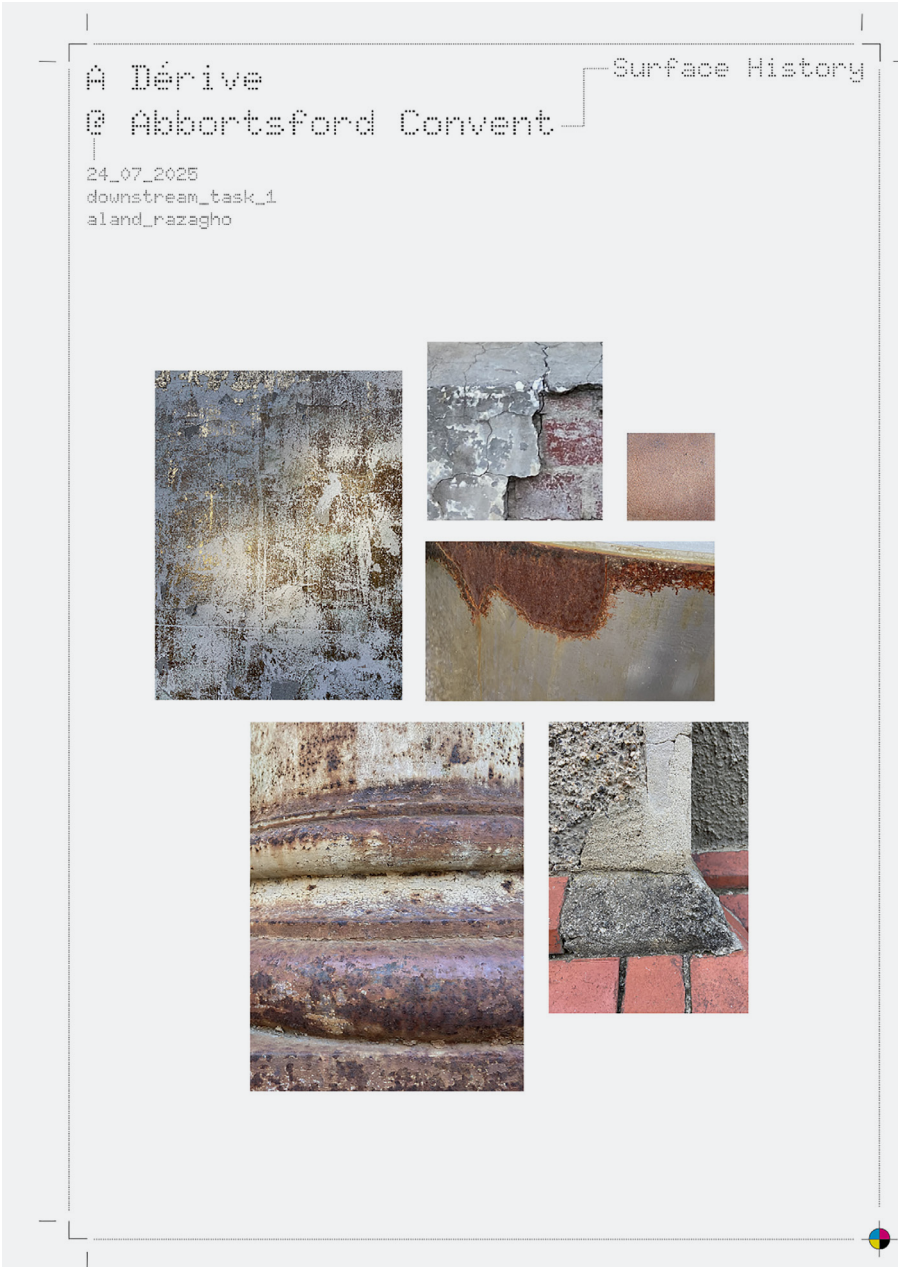


Figure 3. Aland Razagho, dérive observations across the four domains, Downstream: towards an ecological interior, RMIT, 2025.



Figure 4. Reivener Chandra, dendroglyphs mapping time, space, organic and inorganic domains, Royal Botanic Gardens, RMIT, 2025.

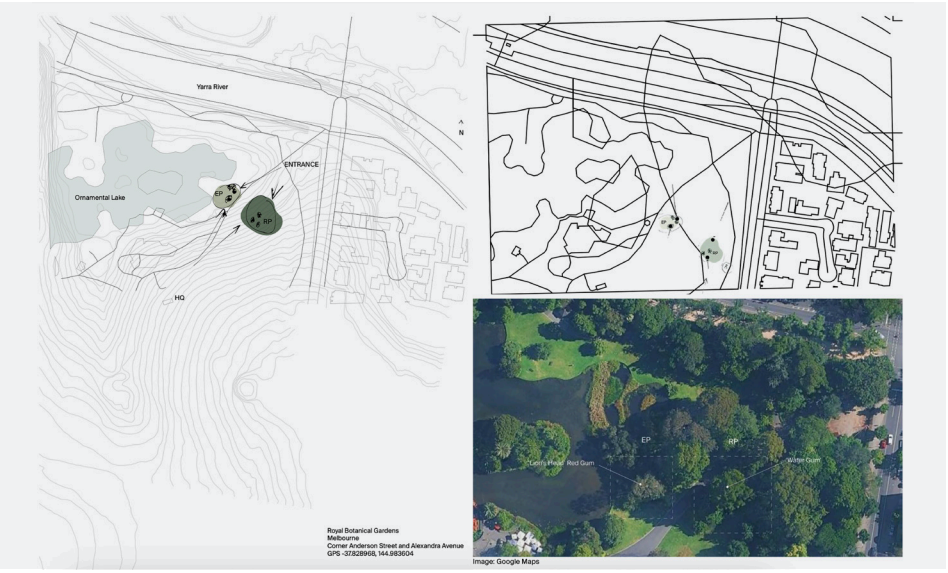


Figure 5. Emma J Davis, dérive map from Royal Botanic Gardens field mapping, Downstream: towards an ecological interior, RMIT, 2025.

Within this framework, the interior designer is reframed as someone who engages with dynamic systems rather than authors homogenised spatial outcomes. Students are encouraged to work with distributed forms of agency, where design propositions are informed by interactions between human and more-than-human actors. This is a practical reorientation of design attention toward variability, responsiveness and interdependence. The dérive is introduced as a tool for cultivating attentiveness and multisensory awareness. Its objective is to shift students from directed observation toward open-ended encounter, allowing them to register spatial conditions through movement, duration and sensory exposure. Aligned with Strauss's (2021) notion of slow research, drifting and lingering help students engage with atmospheres, material conditions and patterns of movement as they unfold (Fig. 2–5).

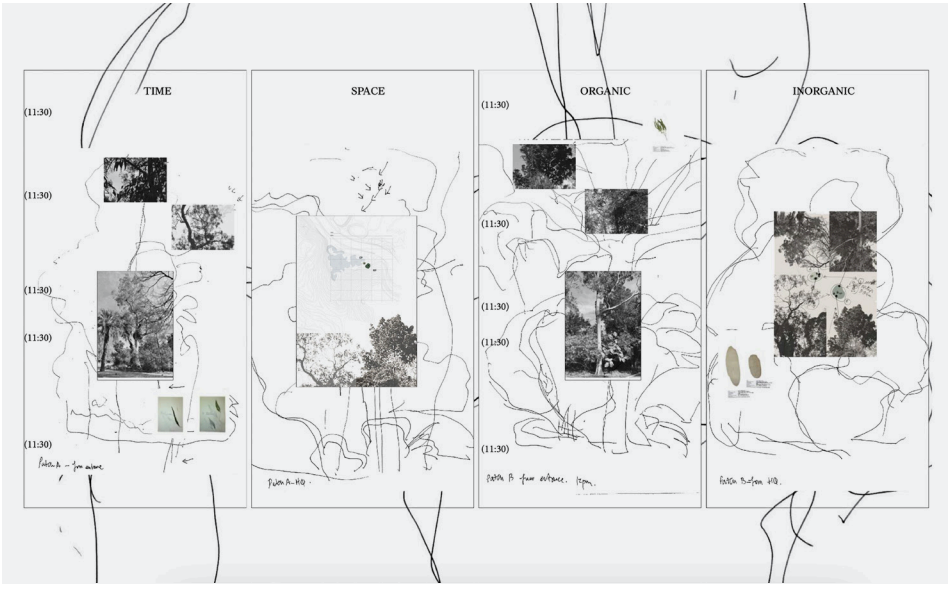


Figure 6. Emma J Davis, spatial mapping across time, space, organic and inorganic domains, Downstream: towards an ecological interior, RMIT, 2025.



Figure 7. Emma J Davis, spatial mapping translated into an environmental window treatment, Downstream: towards an ecological interior, RMIT, 2025.

This process sharpens their ability to sense how space invites gathering, solitude, care, avoidance or curiosity.

Site mapping then translates sensory and relational observations into legible forms. Initially, students analysed two adjacent forest systems at the Royal Botanic Gardens in Melbourne: a dry sclerophyll forest and a rainforest. This pairing foregrounded time as a condition shaping how systems are perceived, function and afford action. Students used cartography, photography, multi-perspectival observation, journalling, written field reflections and diagramming to record patterns across organic, inorganic, spatial and temporal domains (Fig. 6–7).

These mappings made interconnections visible and provided the basis for later design propositions.
The studio approaches translation as a shift in perspective, treating environments as active pedagogical tools. Following Manning and Heiredal (2024), the studio becomes a site for recomposition, where small shifts in conditions foreground alternative ways of learning and knowing. Students reinterpret observations as spatial propositions, or connected sensory tours (Yatmo et al., 2017), understanding space through movement and relation rather than as a static envelope. In this way, interior design is positioned as an evolving practice, aligned with Elizabeth Grosz (2001) and her notion of space as temporal and in continual becoming.

The major project transfers these methods from natural systems into the built environment through the Royal Society of Victoria (RSV), a historic scientific institution and archive in Melbourne.

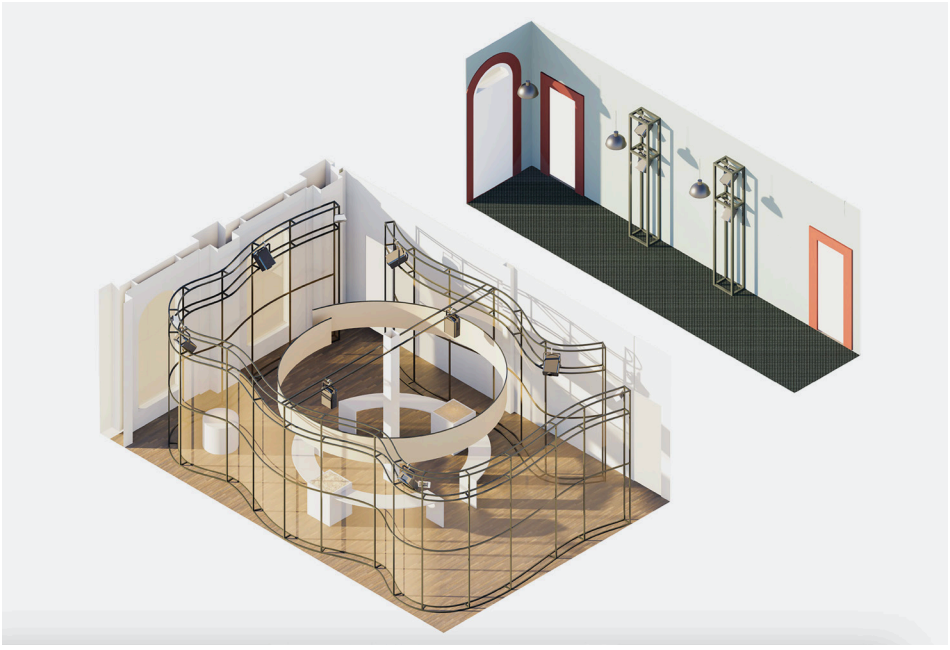


Figure 8. Reivener Chandra, exhibition proposal responding to RSV archive material on rock paintings, Downstream: towards an ecological interior, RMIT, 2025.

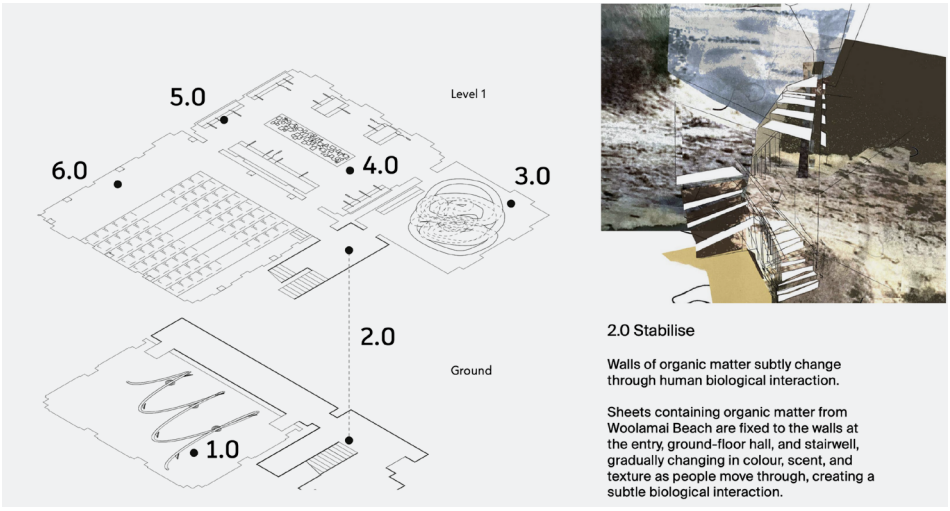


Figure 9. Emma J Davis, exhibition proposal responding to RSV archive material on sand dunes, Downstream: towards an ecological interior, RMIT, 2025.

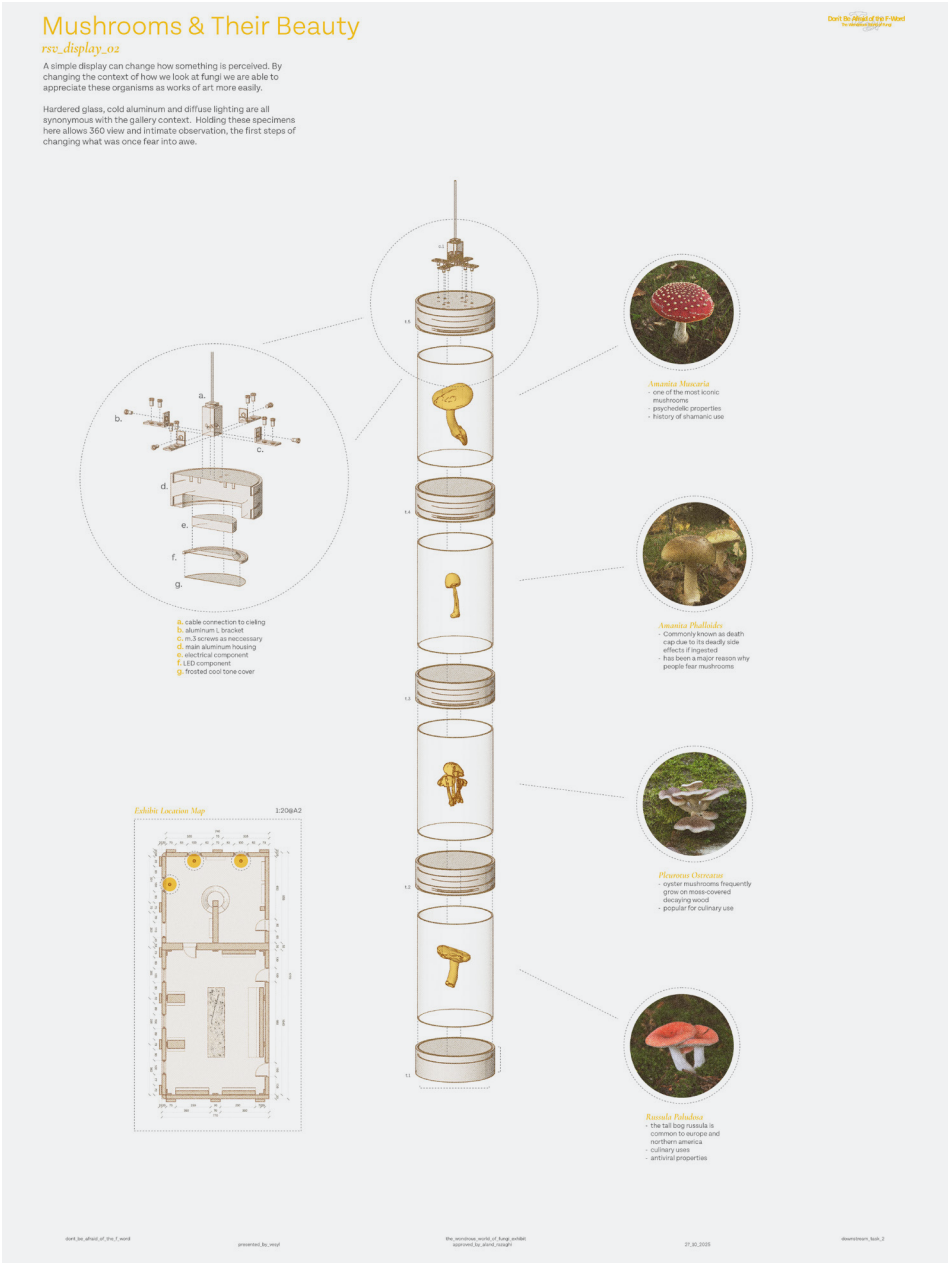


Figure 10. Aland Razagho, propositional design responding to RSV archival articles and datasets, Downstream: towards an ecological interior, RMIT, 2025.

Students undertake slow field study attentive to ecological, spatial and temporal conditions, then use ecosystem mapping to read the site as a network of interacting elements. Observation, photography and written field reflections support the identification of relationships across the four domains (Fig. 8–10), allowing students to reinterpret site features as relational conditions rather than isolated objects.

Ecosystem mapping provides an interface between observation and design, focusing attention on flows, interactions and patterns across systems. Observations are translated into spatial propositions through atmosphere, sequence and material conditions, where representation operates as a way of thinking rather than depiction. Design emerges here as a condition shaped through interactions between people, artefacts, environments and time, rather than as a fixed outcome.

Within the RSV, time becomes an active dimension of the interior through engagement with archival material. Journal articles and datasets are treated as elements to be handled, repositioned and encountered rather than static records. Multisensory installations translate archival material into embodied encounters, allowing information to be felt as well as understood. The interior therefore operates as an evolving system in which knowledge, space and occupation are continuously reconfigured.

4. Conclusions: Multisensory Engagement with Environments as a Designed Practice of Attention and Care

This article has explored how cross-modal engagement with natural environments, particularly through plants as guiding agents, can inform ecological relationships as a foundation

for responsive design. Slow engagement through embodied sensation supports the translation of ideas from natural systems, enabling more nuanced readings of space and helping designers move beyond surface interpretation.
These practices also contribute to sensory literacy (Di Prete & Lonardo, 2026). As multisensory engagement becomes habitual, perception is gradually reconfigured, thickening how spaces are sensed, articulated and interpreted.

Nonhuman actors can therefore operate as intermediaries, revealing latent relations and presences that may otherwise remain unnoticed, highlighting the value of systems-thinking approaches in design practice. This capacity is increasingly important in the context of generative AI, where deeply considered and situated ideas are needed to avoid the homogenisation of creative outputs (Doshi & Hauser, 2024).
More-than-human design challenges the oppositions that have structured Western design disciplines, including nature versus culture, mind versus body, and human versus technology (Forlano, 2017; Braidotti, 2019). Rather than treating these distinctions as fixed, it shifts attention toward relational systems in which human and nonhuman actors co-produce environments (Núñez-Pacheco & Poikolainen Rosén, 2024). Design is therefore understood less as the production of isolated visual solutions than as a situated practice operating through relationships between humans and other-than-human agents, engaging multisensory conditions, environments and time.

This has direct implications for teaching and practice. If design is to engage meaningfully with complex more-than-human

systems, it must develop the capacity to perceive them. Attention becomes a core design skill, enabling designers to register conditions and changes that might otherwise remain unnoticed. The studio work presented here, particularly through the activation of the RSV, demonstrates how this capacity can be developed through spatial and pedagogical methods.

Attentiveness also extends into care as an operational condition of design practice. Puig de la Bellacasa (2017) frames care as the work of maintaining and repairing inhabited worlds, while Tekogul and Forlano (2024) position it as essential to engaging with uncertain and evolving conditions. Attention and care therefore operate together as practical competencies, enabling designers to work with complexity in a responsive and accountable way.

The model also has implications beyond the studio. In professional practice, multisensory ecological attunement can operate as a pre-design method, briefing tool and evaluative framework. Before design begins, it can support site analysis by identifying the sensory, material and temporal relations that structure a place. During briefing, it can expand the definition of users to include more-than-human actors, maintenance systems, seasonal change, archival traces and environmental flows. During evaluation, it can test whether a proposal strengthens or weakens relationships between bodies, materials, atmospheres and time. Scaled in this way, multisensory ecological attunement becomes a practical discipline of noticing, mapping and adjusting relations, shifting design practice from fixed spatial forms toward responsive spatial systems.

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Enhancing Domestic Built Assets through Multisensory Cohabitation

An Organism-Driven Approach to Communal Well-Being

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Multisensory Interiors, Behavioral Reuse, Multispecies Cohabitation, Communal Well-Being, Design Pedagogy as Research.

Abstract
Contemporary approaches to the regeneration of domestic built assets recognize that well-being emerges not from formal upgrades alone but from transformations in everyday behavior and sensory engagement. Within this framework, reuse is understood as a multisensory process through which tactile, spatial, and material coherence reorganizes interactions with interior systems. This paper investigates how multisensory interior systems enhance communal well-being by reframing domestic space as a shared multispecies environment rather than a human-centered setting.
Drawing on embodied architecture theory, interiors are approached as relational systems where comfort and care arise through routines and sensory mediation. Furniture operates as multisensory behavioral infrastructure, reorganizing interiors to support proximity, interaction, and routine formation. The study adopts a research-through-design methodology based on academic studios and comparative case studies addressing spatial compression, infrastructural fragmentation, and aging-oriented environments.
Findings identify three interconnected dimensions of multisensory regeneration: sensory coherence, behavioral synchronization, and perceptual load. Across the cases, these dimensions show how domestic interiors can be reorganized through multisensory alignment rather than physical expansion. The aging-oriented case most clearly illustrates multisensory care infrastructure, showing how accessibility, proximity, and emotional continuity can be supported through interior design interventions.

1. Introduction: Regeneration, Interiority and Communal Well-Being

Recent debates on interior regeneration highlight the potential of existing domestic systems to support psychological and social well-being through multisensory spatial conditions. Interiors are increasingly understood not as static containers of functions, but as relational environments where sensory experience, material presence, and everyday practices converge. Spatial perception emerges through the integration of tactile, thermal, auditory, and spatial cues rather than visual form alone (Spence, 2020), shaping experiences of comfort and belonging.

Within this context, multisensory interior systems are defined as spatial configurations that coordinate multiple perceptual channels – tactile, visual, auditory, and thermal – into coherent experiential structures. Perception is thus understood as a cross-modal process in which the alignment of sensory cues directly influences cognitive load, emotional response, and behavioral patterns. Regeneration, from this perspective, is not limited to physical transformation but emerges through the recalibration of sensory coherence in existing domestic environments.

Research in restorative design shows that multisensory environments can enhance mental health and emotional stability (Pazzaglia & Tizi, 2022; Zhang et al., 2024). Studies on multisensory interior perception further demonstrate that design variables such as materiality, light, and spatial configuration directly influence emotional responses (McTeague et al.,

2025), reinforcing the role of sensory integration in shaping spatial experience (Altay, 2021).

However, current strategies for adapting domestic built assets continue to prioritize formal renovation and technological upgrades, often overlooking the behavioral and sensory dynamics through which interiors are inhabited. This reveals a critical gap: the lack of frameworks capable of linking spatial design with everyday multisensory experience and routine formation. Environmental psychology has demonstrated that spatial stimuli influence emotional responses and behavior (Mehrabian & Russell, 1974), while design operates through what Chaves (2005) defines as the "invisible" organization of environments. Addressing this gap requires a shift from object-based interventions toward approaches that consider how space is experienced, negotiated, and shared. This shift is particularly relevant in contemporary homes increasingly characterized by compact living arrangements, multispecies cohabitation, and evolving routines.

This research investigates how domestic built assets can be regenerated through multisensory configurations that reorganize everyday practices and relationships. It proposes an organism-centered framework in which furniture operates as behavioral infrastructure, mediating interaction among humans and other living organisms. Through three comparative case studies—spatial compression, infrastructural fragmentation, and aging-oriented care—the study examines how multisensory interior systems can reorganize domestic environments into relational settings that support communal

well-being. In doing so, the study positions multisensory interior design as a regenerative strategy that enhances the social, behavioral, and sensory performance of existing domestic built assets through reuse rather than replacement.

2. Theoretical Framework: Interiority as Relational and Multisensory System

Embodied architecture research frames spatial experience as a product of bodily engagement with material environments. Rather than static visual compositions, interiors are understood as multisensory fields in which movement, tactility, temperature, and atmospheric conditions shape perception and behavior. Robinson and Pallasmaa (2021) describe architecture as an anticipatory multisensory system structured through the body, while Pallasmaa (2005) critiques the visual dominance of modern design by emphasizing haptic and embodied perception. Cognitive research further supports this perspective, showing that spatial awareness emerges from the integration of multiple sensory inputs rather than isolated visual information (Spence, 2020). From this standpoint, interiors operate as relational sensory systems that organize how inhabitants perceive, move, and interact (Bruno, 2023).

Within this framework, multisensory interaction is understood as a system of cross-modal correspondences in which stimuli perceived through one sensory channel influence interpretation in another. Material warmth, for instance, may reinforce visual comfort, while spatial continuity can reduce perceptual fragmentation. This perspective allows multisensory experience to function not only as a conceptual lens

but as an analytical tool, enabling the evaluation of interior systems based on their capacity to produce integrated perceptual environments that support behavioral stability and well-being. This approach enables multisensory coherence to function as a qualitative analytical dimension through which interior systems can be comparatively interpreted.

Beyond perception, interiors reflect broader cultural and historical transformations. Rice (2007) links their emergence to evolving notions of domesticity, privacy, and everyday life, positioning space as a mediator of identity and social practices. Interiors are therefore not neutral containers but cultural environments structured through objects, furniture, and spatial hierarchies that shape routines and relationships. In this context, design operates as an "invisible" behavioral infrastructure (Chaves, 2005), where spatial arrangements and material cues guide interaction without explicit instruction. Contemporary domestic environments extend this condition through multispecies inhabitation. Research on pet-human domesticity shows that routines such as resting, feeding, and movement are co-produced through interspecies interaction (Schuurman & Syrjämaa, 2021). Domestic interiors thus function as multispecies systems in which spatial organization mediates relationships across different forms of life.
From a multispecies perspective, domestic environments are not exclusively human-centered settings, but relational ecologies co-produced through interaction, dependency, and embodied coexistence. Haraway (2003, 2008) describes companion species relationships as processes of mutual becoming in which humans and non-human animals continuously

shape each other's behaviors and environments. Similarly, Despret (2016) argues that interspecies relationships emerge through reciprocal practices of attention, affect, and behavioral adaptation rather than passive coexistence. Within interior environments, these perspectives position multispecies cohabitation as an active spatial condition in which routines, proximity, and care are collectively negotiated through material and sensory interaction.

In this study, the term system refers to the coordinated relationships between sensory conditions, spatial organization, routines, and interspecies interaction. Domestic interiors operate systemically because modifications in material continuity, spatial thresholds, or multisensory cues directly influence movement, perception, accessibility, and behavioral synchronization across inhabitants. Furniture, therefore, operates not as an isolated object but as a mediating infrastructure within a relational multisensory network.

Together, these perspectives support a shift from human-centered to organism-centered interiority, where domestic space is understood as a multisensory relational system shaped through embodied interaction, cultural practices, and multispecies cohabitation. Within this framework, regeneration is defined not only through material adaptation but through the recalibration of sensory relationships, behavioral routines, and care-oriented spatial infrastructures that sustain everyday life. This conceptual basis provides the foundation for the research-through-design methodology and defines the comparative analytical dimensions applied throughout the case studies.

3. Methodology: Organism-Driven Design Pedagogy as Research Framework

This study adopts a research-through-design approach in which the design studio functions as an experimental environment for investigating multisensory interior systems. Within this framework, pedagogy operates as a research platform where spatial hypotheses are developed, tested, and refined through observation, prototyping, and iterative design processes grounded in real domestic conditions.

To enable analytical consistency, the study structures multisensory analysis through three qualitative analytical dimensions: (1) sensory coherence, defined as the alignment between material, spatial, and atmospheric cues; (2) behavioral synchronization, referring to the degree to which spatial systems support coordinated routines across inhabitants; and (3) perceptual load, understood as the cognitive effort required to interpret and navigate interior environments. These analytical dimensions provide a structured basis for examining how multisensory configurations influence both perception and everyday practices.

The selection of these analytical dimensions is grounded in recurring themes across embodied architecture, environmental psychology, and multisensory perception research. Sensory coherence derives from studies on cross-modal perception and environmental legibility, behavioral synchronization from research examining the relationship between spatial organization and routine formation, and perceptual load from approaches addressing cognitive effort in spatial interpretation and navigation. Together, these dimensions provide a comparative

framework for examining how multisensory interior systems influence both perception and everyday interaction.

Given the exploratory nature of the study, multisensory analysis focuses primarily on tactile, visual, and spatial dimensions, as these variables were directly observable through the design-research process and consistently documented across all case studies. While auditory, olfactory, and thermal conditions remain relevant components of multisensory experience, they fall beyond the scope of the comparative evidence generated within the studio-based research framework.
The design process involves the analysis of domestic environments through the observation of routines, spatial constraints, and interspecies interactions. Research data consists of observational documentation, behavioral mapping, spatial diagrams, ergonomic analysis, and iterative prototyping developed throughout the studio process. Resulting proposals – furniture systems, diagrams, and spatial configurations – are treated as design-research evidence, allowing multisensory principles and behavioral dynamics to be examined through material and spatial outcomes rather than abstract speculation.

The projects analyzed in this study are treated not as finalized professional implementations but as exploratory design-research prototypes developed within advanced academic studios. Within the research-through-design framework, these projects function as situated investigations capable of generating comparative insight into multisensory interior practices, behavioral mediation, and multispecies cohabitation under specific domestic conditions.

Three projects were selected as comparative case studies for their capacity to represent distinct domestic conditions within a shared framework. Selection is structured around three criteria: spatial scale (compact, dispersed, and aging-oriented environments), organization of routines (negotiated, fragmented, and care-based practices), and interspecies interaction (forms of proximity, accessibility, and shared use). These criteria establish a comparative lens for analyzing multisensory interior systems across conditions.

The analysis employs three complementary tools. Sensory mapping identifies how material qualities, tactile continuity, and spatial thresholds structure perceptual experience. Routine observation examines how domestic practices—including movement, rest, feeding, storage, and care—are spatially organized and transformed through multisensory interventions. Spatial mediation analysis evaluates how furniture systems regulate proximity, accessibility, and interaction between human and non-human occupants. Together, these analytical tools connect sensory experience, material organization, and behavioral outcomes across the comparative case studies. To support comparative interpretation, each case is discussed through qualitative categories (low, medium, high) applied across the three analytical dimensions. These categories are intended as descriptive comparative indicators rather than objective measurements. Sensory coherence is interpreted through the continuity of perceptual cues, behavioral synchronization through the alignment of routines, and perceptual load through the clarity and legibility of spatial organization (Fig. 1).

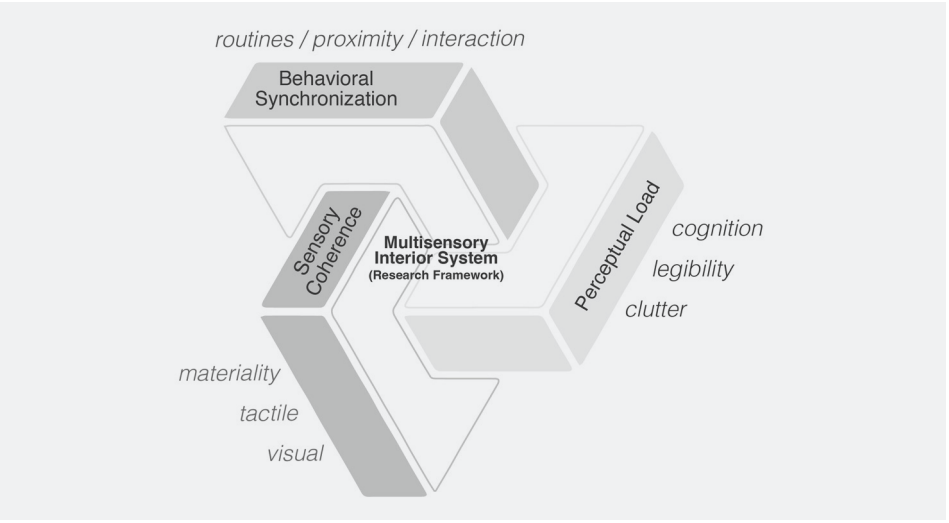

Figure 1. Conceptual framework of multisensory interior systems. The framework is structured through three interrelated analytical dimensions—sensory coherence, behavioral synchronization, and perceptual load—each interpreted through observable spatial and behavioral indicators. Together, these dimensions provide the comparative basis for examining multisensory regeneration across the case studies. Author's elaboration.

While the study does not seek statistical generalization, the comparative framework enables the identification of recurring multisensory and behavioral patterns across distinct domestic conditions.

4. Case studies: multisensory interior systems across domestic conditions

Each case study is analyzed through a consistent multisensory framework examining how spatial interventions reorganize perception, embodied movement, and behavioral routines within domestic interiors. Rather than focusing exclusively on formal or functional attributes, the analysis considers how material continuity, spatial thresholds, and tactile conditions influence comfort, orientation, interaction, and routine stability.

The projects are therefore interpreted not simply as furniture proposals, but as experimental multisensory systems capable of restructuring domestic relationships through sensory mediation and spatial coordination.
Addressing compact interiors, fragmented domestic infrastructures, and aging-oriented environments, the cases demonstrate how regeneration occurs through the reconfiguration of behavioral and sensory relationships within shared domestic space.

4.1. Case 1 – Compact Domestic Environments: *Candicha*

Candicha examines compact domestic environments during COVID-19 lockdown conditions, where prolonged cohabitation intensified conflicts between human routines and the spatial needs of companion animals. Developed by Pedro Álvarez Silva and Carlos Ibarra Díaz (2021) within an academic design research context, the project addresses conditions of spatial compression in multispecies domestic environments. Rather than expanding space or introducing additional objects, the project operates through behavioral reuse, reinterpreting existing typologies to reorganize proximity and routines within a fixed footprint. Observational analysis indicates that conflict arises less from lack of space than from the absence of differentiated yet connected zones capable of supporting negotiated co-presence (Álvarez Silva & Ibarra Díaz, 2021) (Fig. 2).

The intervention reorganizes the interior environment by introducing differentiated yet connected zones that support simultaneous occupation by human and animal inhabitants.

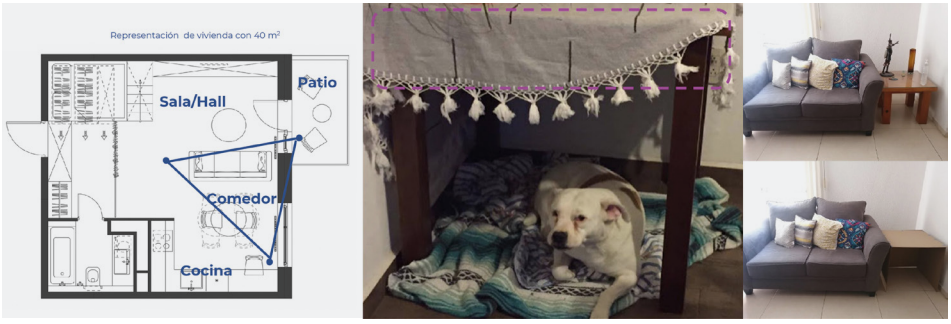

Figure 2. Spatial analysis of activity–context relationships in a 40 m² domestic environment, illustrating overlapping human–animal routines and spatial compression requiring mediated proximity. Adapted from Álvarez Silva & Ibarra Díaz (2021).

Rather than increasing available space, the proposal restructures patterns of movement, visibility, and proximity within the existing domestic layout, transforming the perception and use of a compact interior.

Candicha, a multifunctional coffee table/pet refuge, integrates surface use, storage, and animal resting niches into a stratified system that organizes human and animal bodies across distinct yet connected levels, mediating proximity through calibrated thresholds (Fig. 3).

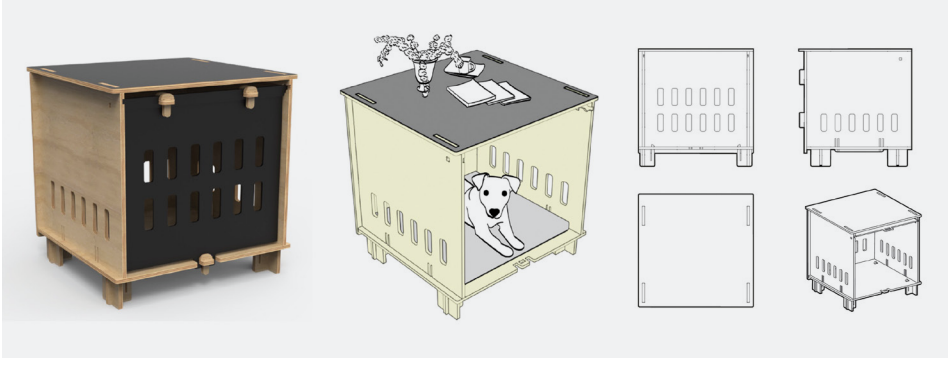

Figure 3. *Candicha* project: Stratified multisensory furniture system integrating tactile continuity, mediated proximity, and layered spatial thresholds to support coordinated coexistence within compact multispecies interiors. Adapted from Álvarez Silva & Ibarra Díaz (2021).

Tactile and visual coherence is established through material and spatial continuity. Pine plywood provides tactile warmth and perceptual consistency, while continuous surfaces and rounded geometries facilitate movement and reduce spatial friction. These qualities support routine stabilization and enable coexistence without forced interaction.

Through multisensory alignment, *Candicha* reorganizes compact domestic interiors by mediating proximity, movement, and coexistence between human and animal inhabitants. Tactile continuity, rounded geometries, and layered spatial thresholds reduce perceptual interruption while facilitating embodied movement within constrained environments. The tactile warmth and visual consistency of pine plywood contribute to sensory coherence, enabling a more stable perceptual environment that supports negotiated routines without requiring strict spatial separation. Behavioral synchronization emerges through stratified proximity, allowing partial alignment between human and animal activities while preserving differentiated zones of occupation. Although the system still requires active negotiation, the intervention appears to reduce perceptual load by organizing coexistence through continuous sensory transitions and mediated interaction.

4.2. Case 2 – Fragmented Domestic Infrastructures: *Faldero*

Faldero examines domestic environments where dysfunction arises not from spatial limitation but from the fragmentation of infrastructural relationships between human and animal inhabitants. Developed by Roman Esparza Pérez and Jocelyn Mendoza Carranza (2026) within an academic design research context, the project addresses conditions in which multispe-

cies routines are spatially dispersed and weakly integrated. Analysis revealed that activities such as feeding, resting, hygiene, and storage occur across disconnected locations, producing parallel behavioral circuits. Pet-related elements are loosely incorporated into the home, reinforcing visual clutter and separating animal practices from human-centered furniture systems (Fig. 4).

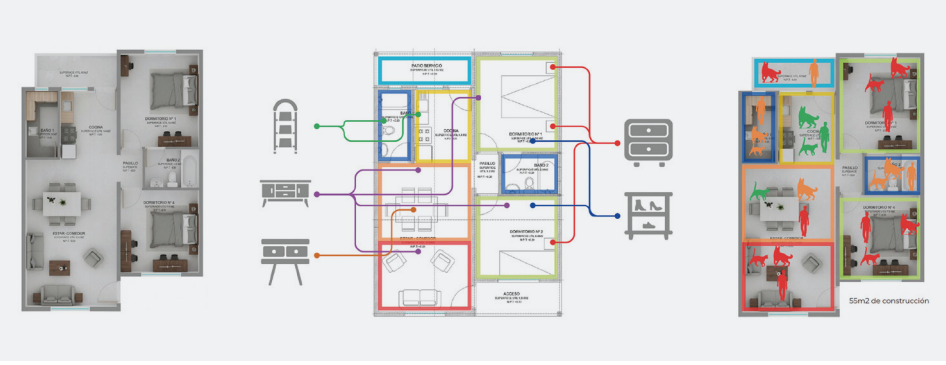

Figure 4. Fragmentation of domestic micro-infrastructures, showing dispersed pet-related objects across household spaces, evidencing lack of integration and resulting discontinuities affecting multispecies routines. Adapted from Esparza Pérez & Mendoza Carranza (2026).

The intervention addresses the interior as a fragmented behavioral environment in which activities occur across disconnected locations. By consolidating dispersed functions into coordinated zones, the proposal increases environmental legibility and strengthens relationships between domestic routines, producing a more coherent multisensory experience of the home.

Faldero responds through typological reintegration, transforming conventional furniture – such as credenzas and auxiliary tables – into multifunctional systems that consolidate multispecies activities within a unified spatial logic.

Feeding platforms, resting cavities, and storage are integrated into continuous multifunctional structures, enabling coordinated use across species (Fig. 5).



Figure 5. *Faldero* project: Integrated multisensory infrastructure consolidating feeding, storage, and resting systems into coherent tactile and visual sequences that stabilize multispecies routines and reduce perceptual fragmentation. Adapted from Esparza Pérez & Mendoza Carranza (2026).

By consolidating dispersed activities into structured zones, the intervention stabilizes routines and fosters proximity. In this case, transformation operates through infrastructural recomposition, converting fragmented domestic systems into coherent multispecies environments. This approach demonstrates how typological furniture systems can reorganize domestic infrastructures (Esparza Pérez & Mendoza Carranza, 2026).

Through multisensory integration, *Faldero* transforms fragmented domestic infrastructures into integrated environments structured through tactile continuity, visual legibility, and coordinated routines. The consolidation of feeding, storage, and resting systems within continuous multifunctional structures reduces perceptual fragmentation and reinforces environmental orientation across multispecies interactions.

Material consistency and unified spatial organization support sensory coherence by minimizing visual clutter and facilitating smoother transitions between domestic activities.

Behavioral synchronization appears to increase as previously dispersed routines become spatially coordinated through integrated furniture systems, while perceptual load is reduced through clearer environmental legibility and continuous movement sequences. Rather than expanding domestic space, the intervention regenerates interior relationships through infrastructural recomposition and multisensory continuity.

4.3. Case 3 – Aging Environments and Multisensory Care Infrastructures: *Tsiina*

The third case study addresses a demographic condition often underrepresented in multisensory interior discourse: aging humans cohabiting with aging companion animals. In this context, domestic space becomes a site where reduced mobility, physical vulnerability, and emotional dependency converge, while companion animals act as affective mediators supporting well-being, routine, and social engagement. The project, developed by Mariana Castillo Banda and Fernanda Morales García (2024), focuses on aging populations within multispecies domestic environments.

The research identifies a condition of dual vulnerability in which both humans and animals experience declining physical capacity and require coordinated spatial support. Conventional domestic arrangements and pet furniture fail to address this shared condition, often increasing physical effort and disrupting interaction (Fig. 6).



Figure 6. Dual vulnerability in aging environments, showing an elderly user bending to interact with a pet, highlighting ergonomic misalignment and physical strain. Adapted from Castillo Banda & Morales García (2024).

The intervention reconfigures the domestic interior as a care-oriented environment in which accessibility, proximity, and everyday interaction become primary spatial concerns. Rather than treating aging as an external condition requiring isolated adaptations, the proposal restructures the interior to support continuous multispecies care within ordinary domestic routines.

The project responds by reframing furniture as a multisensory care infrastructure. Rather than introducing isolated solutions, *Tsiina* integrates seating, resting platforms, feeding zones, and storage within a unified system calibrated to ergonomic, anthropometric, and zoometric requirements (Castillo Banda & Morales García, 2024).

Material and sensory qualities reinforce this accessibility and care approach. The use of planks and beams of solid pine wood, combined with soft natural fiber upholstery and cushioned surfaces, introduces a tactile and visual richness that differs from conventional furniture systems. The natural grain, warmth, and structural qualities of solid pine provide

tactile stability, grip, and sensory familiarity, supporting safe interaction while reinforcing perceptions of comfort and material continuity. Rounded edges and coherent material transitions further enhance safety while maintaining a domestic, non-clinical atmosphere. Rather than relying on uniform industrial finishes, the material system emphasizes natural variation and embodied contact, fostering emotional reassurance, attachment, and continuity within the shared environment.

A key spatial strategy lies in aligning human and animal bodies within shared ergonomic zones. Elevated resting platforms position companion animals within reach, eliminating the need for bending and transforming care routines – such as feeding, grooming, and resting – into accessible and continuous interactions. This alignment supports both physical ease and sustained tactile proximity to reinforce emotional bonds. Care is embedded within everyday spatial experience rather than treated as an auxiliary function (Fig. 7).



Figure 7. *Tsiina* project: Multisensory care-oriented furniture infrastructure aligning ergonomic accessibility, tactile reassurance, and continuous interspecies interaction within aging domestic environments. Adapted from Castillo Banda & Morales García (2024)

This case suggests that the regeneration of domestic built assets in aging contexts may require a shift from functional adaptation toward care-oriented spatial infrastructures. Furniture operates as an active interface that sustains interspecies companionship under conditions of physiological decline. Within the organism-centered framework, this case provides the strongest illustration of the study's central proposition: communal well-being can emerge from interior systems that support vulnerability, proximity, and care. By integrating accessibility, multisensory coherence, and shared routines, *Tsiina* positions interior design as a practice of ethical cohabitation, where regeneration is achieved through the reconfiguration of relationships rather than the replacement of space.

Through multisensory care-oriented design, *Tsiina* transforms aging domestic environments into accessible relational infrastructures supporting both physical and emotional well-being. Tactile warmth, soft material transitions, ergonomic reach zones, and the sensory familiarity of natural wood surfaces contribute to a stable sensory environment that reduces physical strain while reinforcing emotional reassurance under conditions of vulnerability. The spatial alignment of human and animal bodies within shared ergonomic zones enables continuous visual and tactile interaction, embedding care routines directly into everyday domestic experience. Sensory coherence emerges through the integration of material continuity, embodied accessibility, and environmental legibility, while behavioral synchronization is achieved through interdependent routines organized around proximity and assisted interaction. By minimizing perceptual and physical

effort, the intervention illustrates how multisensory interior systems can regenerate domestic environments through care, companionship, and sustained embodied interaction.

Together, the three cases articulate a progression from spatial compression to infrastructural fragmentation and, ultimately, to care-oriented environments. While each responds to a distinct condition, all demonstrate that multisensory interior systems reorganize domestic practices by structuring proximity, stabilizing routines, and aligning multispecies interaction.

Case Study	Sensory Coherence	Behavioral Synchronization	Perceptual Load	Main Multisensory Strategy	Spatial/Behavioral Outcome
Candicha	Medium	Medium	Medium reduction	Tactile continuity and layered spatial thresholds	Negotiated multispecies coexistence in compact interiors
Faldero	High	Medium–High	High reduction	Material continuity and infrastructural reintegration	Stabilization of fragmented multispecies routines
Tsiina	Very High	High	Very High reduction	Ergonomic multisensory care infrastructure	Accessible care-oriented cohabitation and emotional continuity

Table 1. Comparative interpretation of multisensory analytical dimensions across case studies. The qualitative categories presented in this table are intended as comparative interpretive indicators rather than objective measurements.

5. Comparative Analysis and Discussion: Multisensory Regeneration across Scales

5.1. Behavioral Outcomes Across Spatial Scales

Across the three cases, behavioral organization emerges as the primary mechanism through which multisensory interior systems influence domestic life. While the interventions respond to distinct spatial conditions, all demonstrate that routine formation is shaped by the alignment between sensory cues, spatial thresholds, and opportunities for interaction. The comparison suggests that multisensory regeneration does not depend on a specific domestic typology but on the capacity of interior systems to support stable patterns of cohabitation, accessibility, and everyday use. Differences between the cases therefore reflect variations in spatial context rather than variations in the underlying regenerative logic.

5.2. Multisensory Coherence as Regenerative Strategy

The comparative analysis suggests that multisensory coherence functions as a primary mechanism supporting regenerative transformation within domestic interiors. By aligning tactile, spatial, and visual cues, interior systems reduce cognitive friction and enhance perceptual clarity, supporting more stable behavioral patterns. In compact environments, this alignment organizes movement within constrained conditions, reducing spatial stress. In fragmented interiors, it consolidates dispersed activities into coherent zones, reinforcing routine continuity. In aging contexts, it supports accessibility and emotional reassurance by enabling proximity and reducing physical and cognitive effort.

These findings indicate that transformation can emerge through the reorganization of multisensory conditions and everyday routines rather than through spatial expansion or material replacement. Multisensory alignment thus operates as a strategic tool for enhancing both perceptual experience and everyday functioning.

5.3. Furniture as Behavioral Infrastructure

The cases suggest that furniture systems can function as behavioral infrastructures within domestic interiors. Rather than isolated objects, they act as spatial interfaces that organize movement, interaction, and care across species. This perspective aligns with Chaves' (2005) notion of design as an invisible system structuring behavior and with Rice's (2007) understanding of interiors as culturally mediated environments.
Within the organism-centered framework, furniture becomes a multispecies interface that coordinates relationships between human and non-human inhabitants. The aging-oriented case reveals the most advanced application of this condition, where furniture integrates mobility support, tactile reassurance, and shared spatial alignment. Together, these findings support the interpretation of multisensory interior systems as a potentially scalable strategy for the regeneration of domestic built assets across diverse spatial and social conditions.

5.4. Contributions and Methodological Implications

The study contributes to current discussions on multisensory interiors by framing regeneration as a process of behavioral and perceptual reorganization rather than solely material transformation. The comparative framework illustrates how

sensory coherence, behavioral synchronization, and perceptual load can be used as qualitative dimensions for interpreting the relationship between interior environments and everyday practices.

Methodologically, the research expands the potential of research-through-design pedagogy as a source of situated knowledge. By treating academic design projects as exploratory prototypes rather than finalized solutions, the study provides a structured approach for examining how multisensory strategies operate across different domestic conditions while generating comparative insight into multispecies cohabitation and interior regeneration.

5.5. Regeneration of Existing Domestic Built Assets

The comparative findings suggest that the regeneration of domestic built assets can occur through the reorganization of sensory and behavioral relationships rather than through architectural replacement or physical expansion. Across the three cases, the existing domestic environment remains substantially intact; transformation emerges through the strategic reconfiguration of interior systems, routines, and multisensory conditions embedded within the dwelling.

This perspective aligns with contemporary approaches to adaptive reuse that prioritize the enhancement of existing spatial resources over the introduction of new construction. Rather than treating regeneration as a process of material substitution, the projects illustrate how domestic environments can acquire renewed functional, social, and emotional value through interventions operating at the scale of interior systems and everyday practices.

In *Candicha*, regeneration occurs through the reinterpretation of underutilized domestic space, enabling compact interiors to support multispecies coexistence without increasing their physical footprint. In *Faldero*, the reorganization of fragmented domestic infrastructures generates greater continuity between previously disconnected activities, reinforcing the usability and legibility of the existing environment. In *Tsiina*, regeneration emerges through the adaptation of domestic settings to conditions of aging and vulnerability, extending the capacity of the home to support care, accessibility, and emotional continuity over time.

From this perspective, multisensory interior systems function as regenerative mechanisms because they enhance the performance of existing domestic assets through perceptual alignment, routine stabilization, and relational accessibility. The findings therefore support the argument that domestic regeneration can be achieved through the recalibration of sensory experience and behavioral organization, positioning interior design as a strategic tool for extending the social, functional, and affective life of existing built environments.

6. Conclusion

This paper proposes an organism-centered framework for understanding how existing domestic built assets can be regenerated through multisensory interior systems and behavioral reuse strategies. Through three comparative case studies, the research suggests that furniture-mediated multisensory configurations can reorganize domestic routines, structure multispecies interaction, and support communal well-being

through the recalibration of existing sensory and behavioral relationships.

Rather than identifying a single model of domestic transformation, the comparative analysis demonstrates that regeneration emerges through context-specific forms of multisensory adaptation. Across the cases, the common factor is not the type of intervention but the capacity of interior systems to improve accessibility, reinforce routine stability, and support meaningful forms of cohabitation within existing domestic environments.

Among the three cases, the aging-oriented intervention most clearly illustrates the potential of multisensory care infrastructures to address vulnerability through spatial and sensory support. Its emphasis on accessibility, proximity, and embodied interaction highlights how interior design can contribute to long-term well-being without requiring substantial architectural modification.

These findings support an understanding of interior design as a regenerative practice grounded in behavioral organization, sensory experience, and relational cohabitation. Rather than prioritizing replacement, the study suggests that domestic well-being can emerge through the recalibration of existing interior systems and the reinforcement of meaningful interactions over time. Future research may expand this framework through post-occupancy studies and longitudinal observation of multispecies domestic interaction beyond academic design-research contexts.

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