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**MULTISENSORY
INTERIORS**

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PAD. Pages on Arts and Design

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ANVUR Class A Journal – Area 08, Sector 08/C1
Design and Technological Design of Architecture

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Publisher**AIAP Edizioni**

Associazione italiana design della comunicazione visiva

via A. Ponchielli 3 – 20129 Milano – Italy

aiap@aiap.it – www.aiap.it

PAD © ISSN 1972-7887

#30, Vol. 19, June 2026

www.padjournal.net

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MULTISENSORY INSTALLATIONS

Beyond “Seeing”

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

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Keywords

Communicative Accessibility, Multisensory Design, Synesthetic Design, Museum Accessibility, Information Consistency.

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.

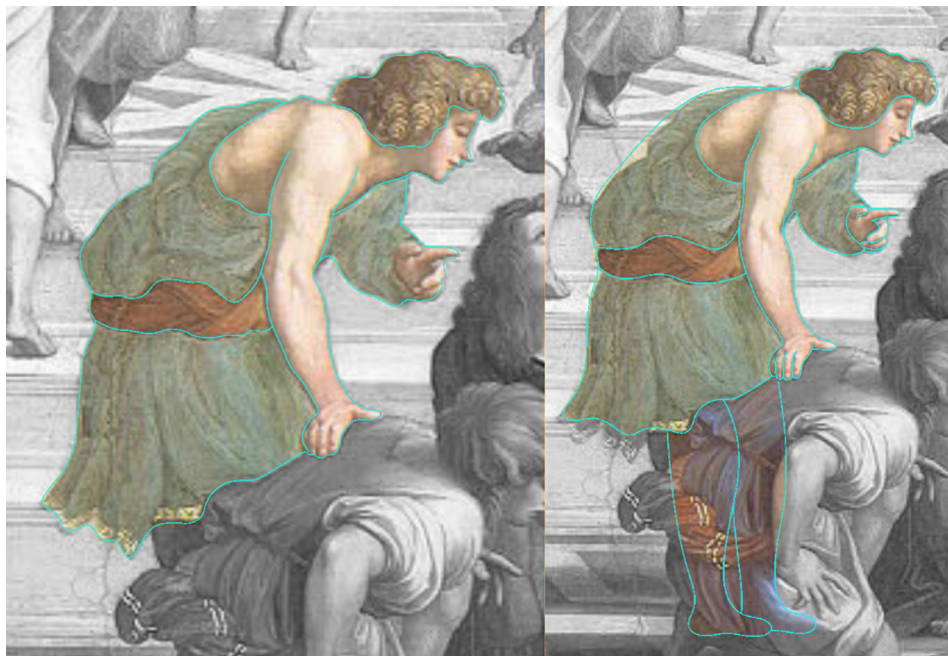


Figure 1. Raffaello Sanzio, Scuola di Atene (1509-1511), a figure in the painting as the source of the tactile prototypes; the detailed version of the outline (left) and simplified version of the outline, created by Weihuan Hou, 2026.

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	Step 1: Assembly the Puzzle Step 2: Fill out the Questionnaire
	Group 6	Sighted + Audio Description	
D Without Audio Description	Group 7	Texture Version + Blindfolded	
	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.

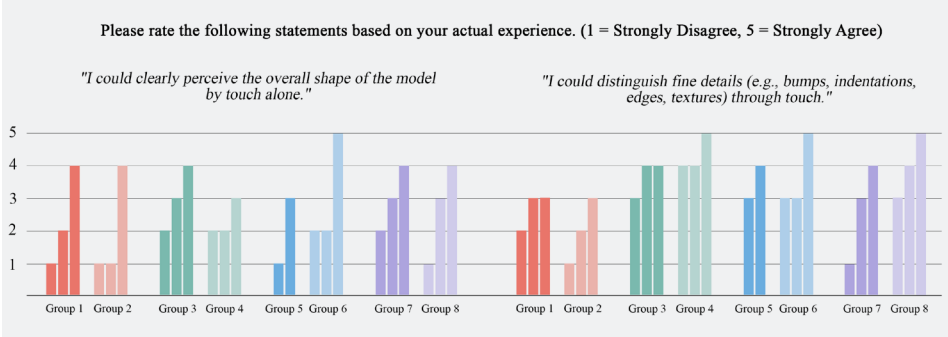


Figure 4. Data 1 of the answers to rate participants’ tactile experiences.

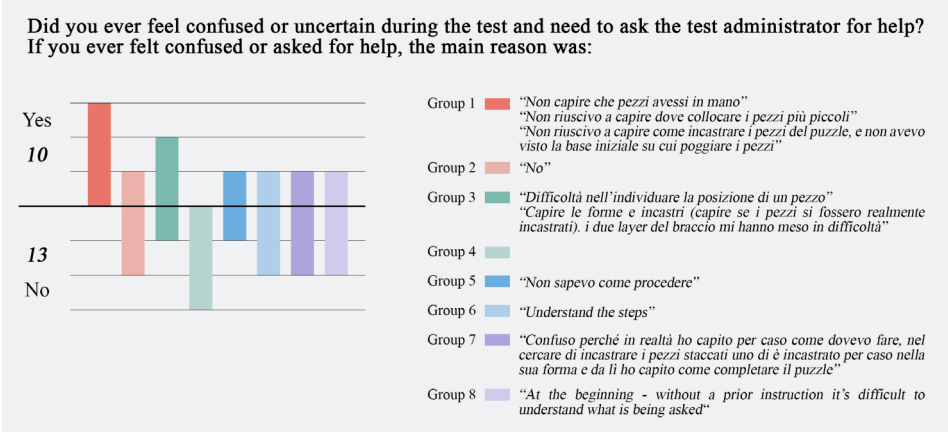


Figure 5. Data 2 of the answers to the question “Did you ever feel confused or uncertain during the test and need to ask the test administrator for help?”. Some of the answers in Italian have been translated into English.

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).

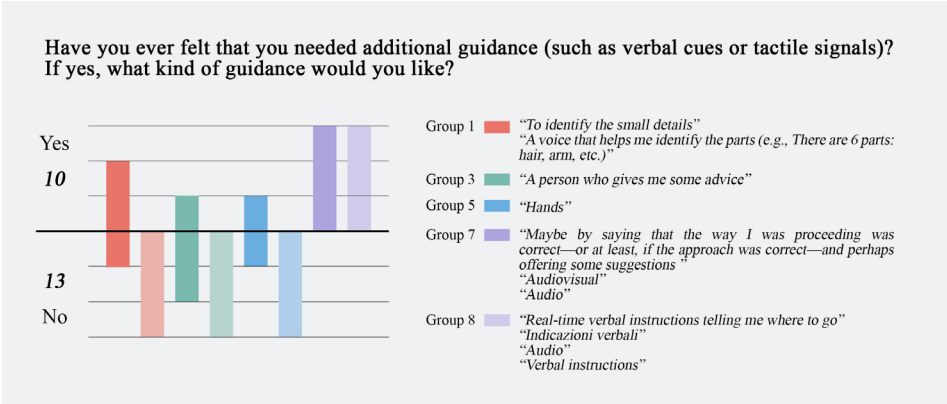


Figure 6. Data 3 of the answers to the question “Have you ever felt that you needed additional guidance (such as verbal cues or tactile signals)?”. Some of the answers in Italian have been translated into English.

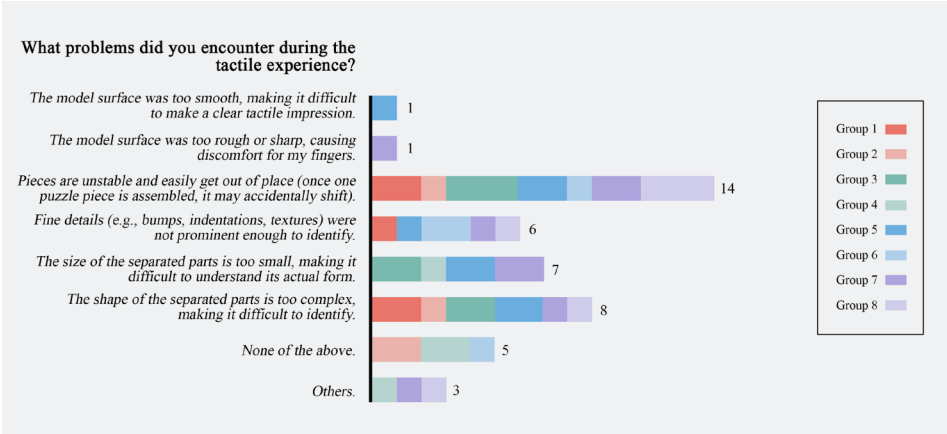


Figure 7. Data 4 of the answers to the question “What problems did you encounter during the tactile experience?”.

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.

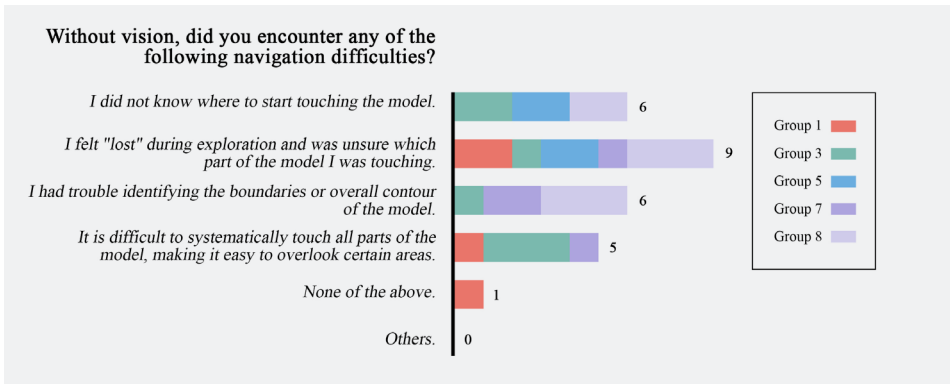


Figure 8. Data 5 of the answers to the question “Without vision, did you encounter any of the following navigation difficulties?”.

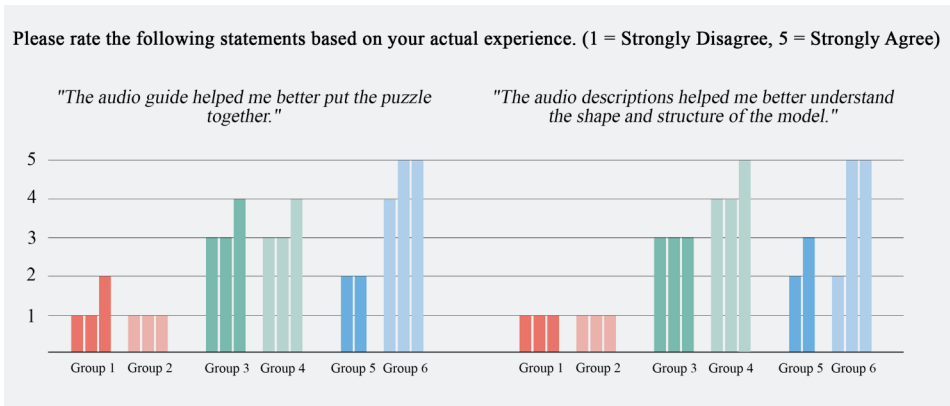


Figure 9. Data 6 of the answers to the rate participants’ audio experiences.

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.

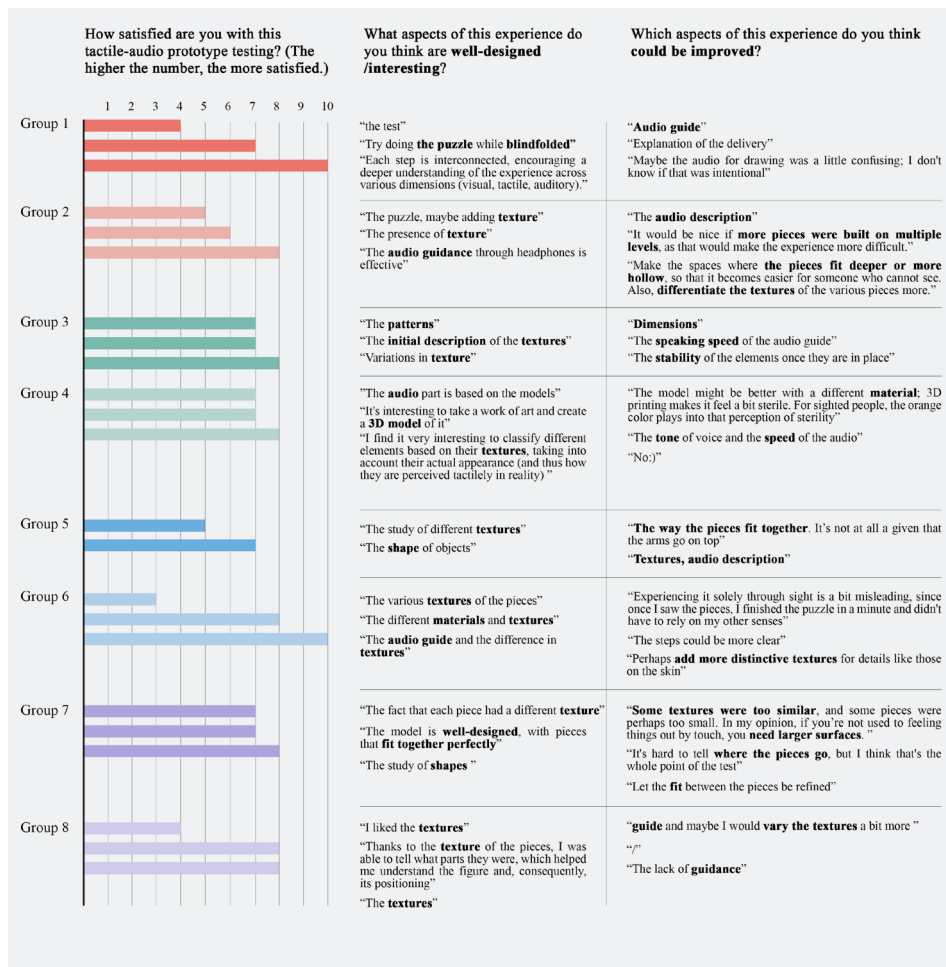


Figure 10. Data 7 of the answers to the overall experiences. Some of the answers in Italian have been translated into English.

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

Financial support from the China Scholarship Council (CSC) is gratefully acknowledged (Grant No. 202307820050).

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V

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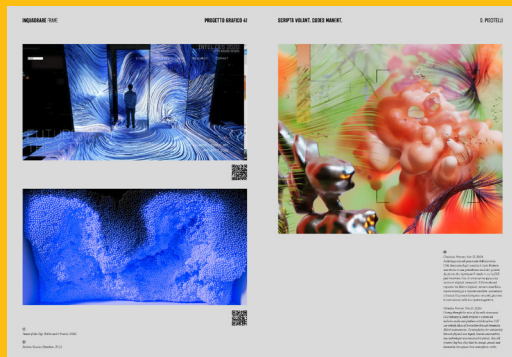
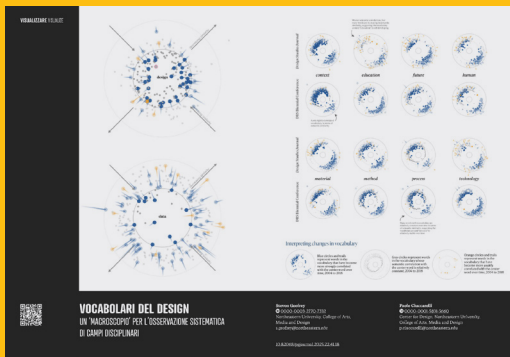
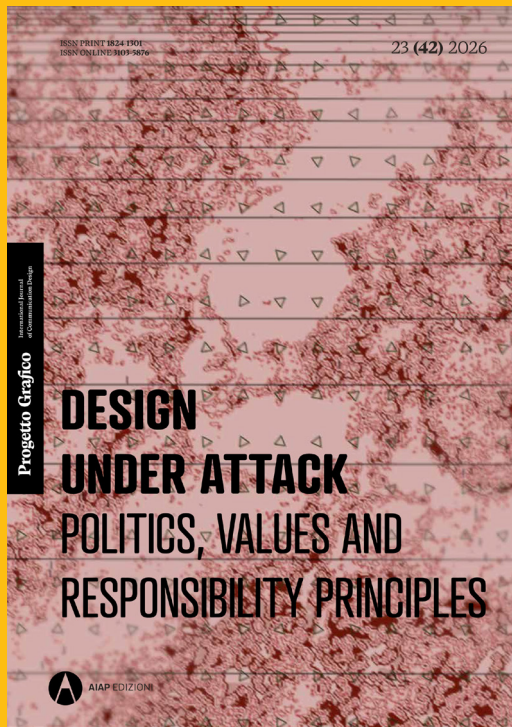
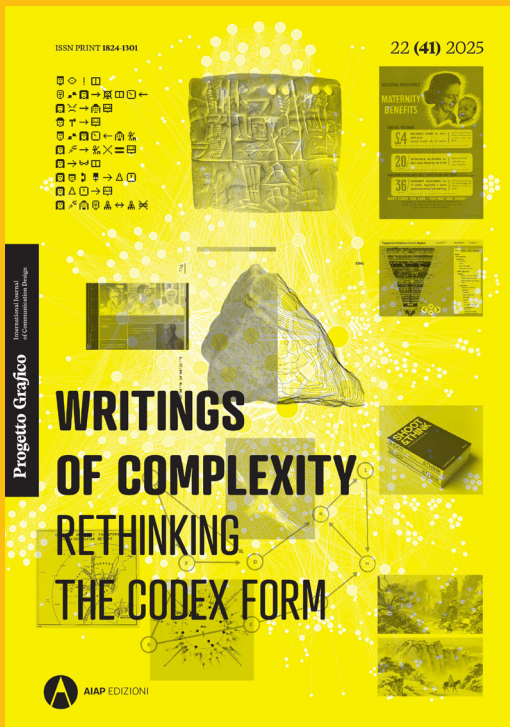
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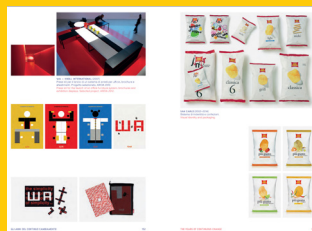
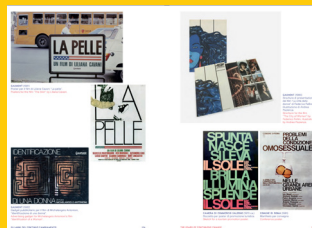
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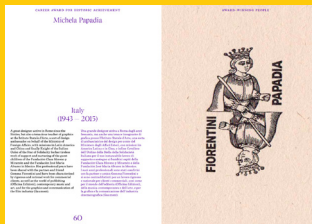
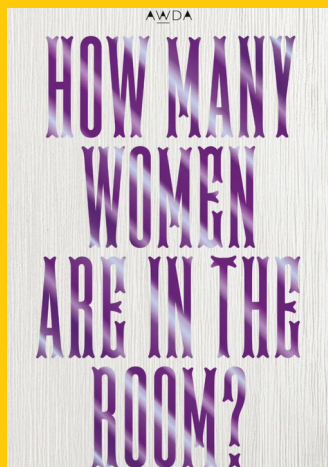
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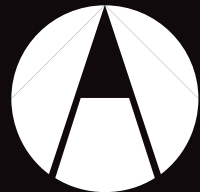
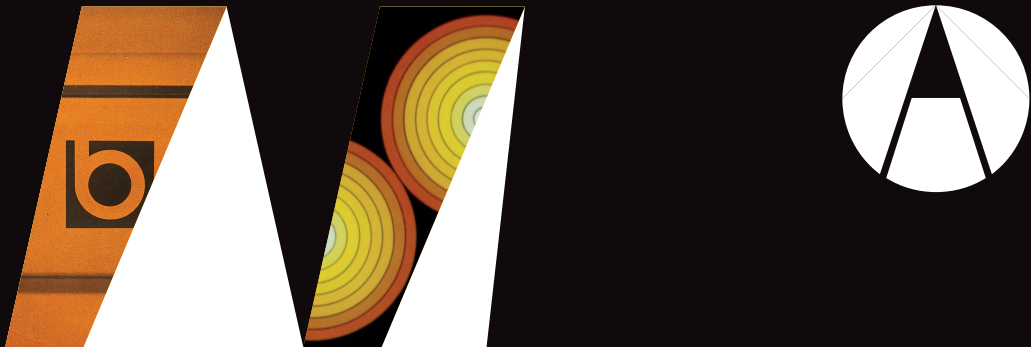
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PAD. Pages on Arts and Design

International, peer-reviewed,
open access journal
ISSN 1972-7887

#30, Vol. 19, June 2026

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