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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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REUSE AND REGENERATIVE BEAUTY

Disaster-Affected Spaces as Multisensory Living Labs

Comfort and Regeneration through the Reuse of Abandoned Spaces

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Keywords

Multisensory Living Labs, Adaptive Reuse, Post-Earthquake Architecture, Comfort Pattern, Regenerative Design.

Abstract

Disaster-affected environments are often framed as remnants to be secured, remembered, or replaced, overlooking their potential as multisensory spaces where perception, memory, and embodied experience intersect. This paper reinterprets post-earthquake abandoned architectures as multisensory living labs, where interior and spatial design support both experimental practices and organism-centered well-being. Drawing on cross-modal correspondences, environmental psychology, and neuroscience-informed design, the study examines how the coherence of light, sound, materials, smell, and microclimate influences orientation, perceived safety, and stress regulation.

The research is based on two case studies from the Horizon 2020 Search & Rescue project: Poggioreale (Italy) and a semi-collapsed building in Madrid (Spain). Through comparative sensory mapping and a user-centered approach, the paper identifies comfort patterns that support spatial legibility, embodied interaction, and cognitive clarity.

The study argues that disaster-affected spaces can be reinterpreted as experimental commons, where regeneration occurs through the activation of multisensory qualities, positioning design as a driver for resilience and adaptive reuse.

1. Post-Disaster Abandoned Spaces as a Design Resource

In contemporary landscapes, abandoned spaces constitute a widespread and often problematic condition. Former industrial buildings, closed shopping centers, amusement parks, and other public or private spaces have progressively lost their function and symbolic meaning (Pannofino, 2020). Deprived of activities, rituals, and social relations, they often become residual parts of urban experience.

A particularly complex category is represented by spaces abandoned following disasters such as earthquakes, floods, or explosions. In these cases, abandonment is not only the result of the catastrophic event but also of socio-economic fragility, territorial vulnerability, and reconstruction processes, often limited to safety measures. This approach tends to reduce interventions to technical operations, while overlooking the perceptual, symbolic, and relational value of these environments.

Recent studies in environmental psychology and neuroscience applied to design show that spatial experience emerges from multiple sensory stimuli and from the embodied interaction between body and environment (Haverkamp, 2025; Mallgrave, 2015; Pallasmaa & Robinson, 2021). Post-disaster spaces can be understood as complex multisensory environments, where light, sound, materiality, and atmosphere contribute to meaningful experiences.

This paper reinterprets these spaces as *multisensory living labs*: real contexts in which perceptual experience can be observed and designed. Unlike controlled laboratories, they offer

dynamic and unpredictable conditions for studying human behavior in situations of uncertainty. The European Union itself promotes the adoption of *Living Labs* as user-centered environments for co-creation, experimentation, and validation of innovative solutions (Desole, 2026; Schuurman et al., 2011).

Post-disaster environments are not merely unused spaces, but places marked by trauma, memory, and resilience. As palimpsests of memory, they retain material traces of past events and contribute to place identity (Ellard, 2015). Instead of treating them as voids to be filled, this paper considers them design resources able to generate new forms of experience through adaptive reuse.

2. Interior and Spatial Design as a Practice of Reactivation

In post-disaster reuse, interior design, spatial design, and wayfinding systems can mediate the relationship between body, environment, and perception, without invasive structural intervention. Rather than demolition or reconstruction, this perspective favors light, reversible, and low-impact actions capable of transforming the perceptual quality of space while preserving its identity.

This approach also responds to environmental and economic concerns: disposal, demolition, and rebuilding involve high energy, material, and financial costs. Adaptive reuse extends the life cycle of existing spaces and turns them into flexible environments. Design can act on the sensory dimension through temporary lighting, chromatic differentiation, textile and sound-absorbing elements, and reversible pathways or plat-

forms. These interventions enhance orientation, reduce perceptual ambiguity, support embodied anchoring, and improve accessibility without compromising the existing fabric. Design therefore operates not on the load-bearing structure, but on the sensory experience of the place. It transforms the ruin into a temporary, legible, and inhabitable interior, reactivating its experiential potential and allowing new uses, from cultural production to technological experimentation.

3. Case Studies

The research adopts a qualitative, research-through-design approach combining literature review, comparative case study analysis, and sensory mapping. The analysis focuses on the embodied experience of first responders and users interacting with unstable environments, exploring how multisensory conditions influence orientation, perception, and action in post-disaster contexts.

The two case studies were developed within the Horizon 2020 *Search & Rescue* project, where abandoned environments were used as testing grounds for technologies and operational procedures. Although different in historical, spatial, and symbolic terms, Poggioreale and the Madrid site share strong perceptual intensity generated by instability, fragmentation, and material degradation. This makes these places relevant for a reflection on multisensory reuse and adaptive regeneration. Within the *Search & Rescue* pilot activities, these environments provided realistic conditions in which perceptual, operational, and spatial dynamics interacted. Light variation, acoustic reverberation, deteriorated materials, dust, and spatial discon-

tinuities affected spatial understanding, decision-making, and the embodied experience of first responders.

The reuse of abandoned architecture can thus enhance multisensory qualities, turning ruins into spatial configurations that support engagement, orientation, and new forms of interaction. It also reinforces memory and identity through the material and symbolic traces they embody.

3.1. Poggioreale: Memory, Identity, and Social Regeneration

Poggioreale is a small town located in the Belice Valley, in western Sicily (Italy), abandoned after the 1968 earthquake. Today, the site is partially accessible through controlled visits aimed at preserving the structures and limiting access to dangerous areas. Despite decades of abandonment, its urban fabric remains recognizable: streets, public buildings, churches, and fragments of domestic architecture still reveal the original configuration of the village.

The site is characterized by collapsed roofs, deteriorated surfaces, debris, exposed walls, and environmental exposure. Natural light enters roofless buildings, creating shifting contrasts and shadows; sounds reverberate in empty spaces; dust, wind, and material decay contribute to a dense multisensory atmosphere. These conditions create an immersive perceptual environment, in which the relationship between body, matter, and space becomes particularly intense.

Within the Horizon 2020 *Search & Rescue* project, Poggioreale was used as a full-scale simulation environment for rescue operations conducted in April 2022 (Fig.1).



Figure 1. Laura Giraldi and Francesca Morelli, “Use Case 1: Victims trapped under rubble” in Poggioreale (Sicily, Italy), pilot activity on search and rescue operations, 2022.

Several areas of the historic center, including the former nursing home, church, and hospital (Chalaris et al., 2021a), were used as operational scenarios because their structures remain legible enough to support realistic emergency simulations.

The use of the site remains compatible with its historical and symbolic identity. The ruins do not merely function as operational settings, but as environments capable of activating emotional, sensory, and cognitive responses. The interaction between responders, abandoned architecture, and unstable spatial conditions generated a specific embodied experience strongly influenced by the multisensory qualities of the place. Deteriorated surfaces, amplified sounds, dust, natural light, and atmospheric conditions shape a complex perceptual environment, fostering spatial awareness and direct interaction between body and matter.

Beyond emergency simulations, Poggioreale offers opportunities for cultural and social regeneration. Its emotional and narrative dimension makes it suitable for artistic events, cultural initiatives, and audiovisual productions, where sensory authenticity becomes central. The site can therefore be understood not only as a memory landscape, but also as a potential cultural infrastructure able to reconnect the community with its territorial identity.

Through performances, exhibitions, workshops, and collective initiatives, the abandoned village could evolve into a distributed cultural hub, reinforcing social cohesion and counteracting depopulation processes.

In this sense, the project does not generate value ex novo, but reveals, preserves, and amplifies a value already embedded in the place.

3.2. Madrid: Operational Infrastructure and Experimental Flexibility

The second case study concerns a group of abandoned buildings in a rural area on the outskirts of Madrid (Spain) (Fig.2). The site is isolated, marginal, with limited accessibility and a lack of significant urban relationships. Unlike Poggioreale, it does not possess consolidated historical or symbolic value. The structures are abandoned, with partially collapsed walls, deteriorated elements, and large interiors without maintenance.

These conditions make the site suitable for simulating emergency scenarios, as it resembles post-earthquake destruction settings. Within the Horizon 2020 *Search & Rescue* project, the site was selected as a testing ground for complex rescue operations involving unstable conditions, including the release of flammable gas and the introduction of smoke and odor-based stimuli (Chalaris et al., 2021b).

During the pilot activities, artificial stimuli intensified the multisensory conditions of the site and reproduced realistic emergency situations. Smoke, odors, damaged surfaces, structural discontinuities, and unstable environmental conditions generated a high-intensity perceptual environment, enabling the testing of technologies, operational procedures, and responder behavior.



Figure 2. Search & Rescue Project team, “Pilot – Use Case 7: Chemical Substances Spill” in Madrid, pilot activity on emergency response to a chemical spill, 2022.

As in Poggioreale, the deteriorated spatial configuration influences environmental perception. Damaged surfaces, structural openings, and missing wall sections create a dynamic relationship between interior and exterior spaces, affecting orientation, spatial understanding, and decision-making. Unlike Poggioreale, however, the value of the Madrid site does not derive from collective memory or symbolic heritage, but from its ability to function as an operational, experimental, and productive infrastructure. Its flexibility allows continuous re-configuration, transforming a marginal abandoned space into a platform for research, innovation, audiovisual production, crash testing, and multisensory experimentation.

4. Comfort Patterns: Toward a Dynamic Definition of Comfort

The comparative analysis identifies five recurring principles, here defined as *comfort patterns*, which describe how space can support orientation, perception, and action in post-disaster environments characterized by instability, fragmentation, and high sensory intensity. These patterns are not prescriptive solutions, but adaptive design strategies responding to the specific conditions of each context.

Comfort is not understood as a static condition of well-being, but as a dynamic process of perceptual and cognitive regulation through which individuals orient themselves, understand, and act under unstable conditions. In post-disaster environments, comfort patterns do not correspond to conventional stability or protection, but to the capacity of space to support cognitive clarity, orientation, and embodied interaction. This interpretation aligns with restorative design, which highlights the role of the environment in psychophysical recovery (Pazzaglia & Tizi, 2022).

The two case studies show how interior and spatial design can transform instability from a critical factor into a design resource.

Sensory Coherence

Coherence among sensory stimuli enables more effective perceptual integration, faster cognitive responses and greater interpretive clarity (Mallgrave, 2015). In post-disaster contexts, where sensory overload and environmental ambiguity are common, the alignment of visual, acoustic, tactile, and environmental stimuli becomes essential for reducing cogni-

tive stress and facilitating orientation. When stimuli are congruent, the cognitive system can process information more efficiently, reducing cognitive load and enhancing clarity. Conversely, sensory incoherence in degraded or unstable environments increases disorientation and fatigue. Design can therefore orchestrate stimuli, even with minimal devices, to re-establish a coherent relationship between perception and space.

Design implication: The alignment of lighting, materials, and acoustic cues can be used to reduce perceptual ambiguity and enhance cognitive clarity in unstable environments. The alignment of lighting, materials, textures, and sound cues can reduce perceptual ambiguity and improve cognitive clarity in unstable environments.

Spatial Legibility

Spatial legibility is the ability of an environment to communicate its organization and make paths, hierarchies, and relationships understandable. In post-disaster scenarios, fragmentation and collapse compromise the readability of space. Recognizable elements, such as residual structures, landmarks, material transitions, or lighting variations, can support mental maps and improve perceived safety (Lynch, 1990). Interior design can reinforce these elements without invasive interventions.

Design implication: Designers can reinforce spatial legibility through wayfinding systems, light gradients, and material differentiation to support orientation, spatial comprehension and perceived safety without altering the identity of the site.

Embodied Anchoring

Spatial experience is deeply embodied. Embodied anchoring refers to the relationship between body and environment through touch, movement, balance and proprioception. In unstable environments, irregular surfaces, changes in elevation, and material discontinuities activate a continuous bodily awareness. Temporary pathways, platforms, supports, and tactile references can strengthen the body-space relationship and improve safety.

Design implication: Tactile surfaces, reversible platforms, temporary support and physical reference elements can strengthen the body-space interaction, improving stability, awareness, and protection.

Refuge Zones

In high-intensity sensory environments, *micro-refuge zones* become essential for cognitive and emotional regulation. These are areas where stimulation is reduced or controlled, allowing pause, recovery, and perceptual reorganization. They may emerge through shadows, protected interiors, or quiet areas, or be designed through lightweight interventions such as textiles, screens, acoustic buffers, or controlled lighting.

Design implication: The design of micro-refuge spaces using soft materials, filtered light, and acoustic buffering can support emotional regulation and cognitive recovery without modifying the existing structure. Lightweight and reversible interventions can create micro-refuge spaces that support emotional regulation and temporary recovery without modifying the existing structure.

Biophilic Devices

Natural elements contribute to physiological and psychological comfort. Light, airflow, vegetation, water, and natural materials can reduce stress and improve the environmental quality of the experience. In post-disaster environments, biophilic elements may already be present or can be integrated through minimal and reversible strategies.

Design implication: Integrating natural elements such as natural light, ventilation, vegetation, and water can support physiological well-being, reduce stress and improve the sensory quality in high-intensity environments.

Taken together, these patterns show that comfort does not eliminate complexity or instability, but makes such conditions legible, orienting, and cognitively sustainable.

Rather than neutralizing instability, *design can* transform it into a meaningful and inhabitable experiential condition.

5. Interior and Spatial Design: Models of Reuse and Multisensory Infrastructures

The analysis of comfort patterns redefines the role of design in the reuse of post-disaster spaces, shifting the focus from material transformation to perceptual activation. Interior and spatial design operate as mediating practices between body and environment, intervening through light, reversible, and low-impact devices. Light, textiles, platforms, and temporary systems can re-establish coherence among sensory stimuli, enhance spatial legibility, provide embodied anchoring, and introduce comfort without altering the existing structure.

The comparison between Poggioreale and Madrid outlines two complementary models of reuse. In Poggioreale, comfort patterns emerge largely from the historical structure and material stratification of the site. Sensory coherence is generated through the interaction of light, material, and sound; spatial legibility derives from the persistence of the original urban fabric; refuge zones and biophilic elements are already embedded in the environment. Here design works through revelation and amplification, enhancing what is already present.

In Madrid, by contrast, comfort patterns must be constructed through design and simulation. Sensory coherence is achieved through the orchestration of stimuli; spatial legibility is supported by artificial devices; refuge zones compensate for perceptual intensity; and the biophilic dimension remains an unexplored opportunity. Here, the value of the space is not intrinsic, but emerges through use and design activation.

These two models, *memory-based* and *performance-based*, are complementary. They show that the value of abandoned spaces is constructed through modes of activation, perceptual conditions, and degrees of transformability. Post-disaster spaces can therefore become multisensory infrastructures for research, training, cultural events, and audiovisual production. In a context increasingly dominated by digital simulation, their sensory authenticity remains a distinctive and non-replicable value. Reuse becomes a process of perceptual regeneration, in which design does not replace the existing, but reactivates it through experience.

6. Conclusions: From Ruins as Voids to Ruins as Perceptual Infrastructures

This paper has reinterpreted post-disaster abandoned spaces not as voids to be filled, but as active multisensory environments capable of generating experience, knowledge, and new uses.

Through the analysis of the Poggioreale and Madrid, it has shown that reuse does not necessarily rely on material transformation but can occur through the activation of perceptual qualities already embedded in space. Similar dynamics can be observed in other post-disaster regeneration contexts, where abandoned environments have been progressively reactivated through cultural, social, or experimental practices.

The main contribution lies in the introduction of *comfort patterns* as interpretative and design tools. In unstable and high-intensity sensory environments, comfort does not coincide with control, but with the capacity of space to support orientation, cognitive clarity, and embodied interaction. The case studies highlight two complementary modes of reuse: one grounded in memory, identity, and emotional engagement, and one based on performance, adaptability, and experimentation.

Within this process, interior design acts as a perceptual mediation. Through reversible devices, such as lighting, textiles, and pathways, it can transform the experience of space without altering its structure. This approach also represents a sustainable strategy, avoiding invasive interventions while

enhancing the existing fabric. Post-disaster spaces can thus become permanent multisensory infrastructures for technological experimentation, cultural production, and audiovisual practices, contributing to their reintegration into the contemporary landscape.

In contexts increasingly shaped by digital and simulated environments, these spaces offer a sensory authenticity: a dimension that cannot be fully reproduced artificially and that significantly enhances perceptual experience and emotional engagement (Ellard, 2015). The reuse of abandoned spaces, understood as a cultural and design-driven process, redefines the relationship between body, space, and environment. The ruin ceases to represent loss and becomes a perceptual infrastructure capable of generating experience, knowledge, and regeneration, reaffirming the role of embodied experience in contemporary design (Mallgrave, 2015; Pallasmaa & Robinson, 2021).

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Master's degree with honors in Psicologia per il benessere: empowerment, riabilitazione e tecnologia positiva from Università Cattolica del Sacro Cuore, Milano. Thesis *Il flow come mediatore psicologico per la progettazione di un museo rigenerativo: uno studio neuroscientifico*. Since 2024, teaching support in the Museology and Museography courses, in collaboration with Professor Alessandra Squizzato, at Università Cattolica del Sacro Cuore. In 2025, monographic lecture *Psico-Neuroarchitettura* in collaboration with Professor Anna Anzani, at Scuola di Design of Politecnico di Milano.

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PhD student at the Department of Design of the Politecnico di Milano. She obtained a master's degree in design & engineering with a thesis on the semiotic interpretation of cultural heritage at the Politecnico di Milano. Her research is currently aimed at exploring the new possibilities and solutions of communication design in the context of museum accessibility through synaesthetic translation and multisensory experience.

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Emilio Lonardo

Designer, researcher and educator based in Milan. He holds a PhD in Design and teaches at Politecnico di Milano, where his academic work focuses on the relationships between spatial experience, public space, emerging technologies and psychological well-being. His research investigates how design can contribute to more responsive, inclusive and meaningful environments, with particular attention to urban interiors, augmented reality, phygital interaction, gentle technologies and design-led cultural innovation. He has collaborated with universities, cultural institutions and international partners on research projects, workshops and educational programmes exploring the role of design in shaping contemporary forms of living, learning and participation. Alongside his academic activity, he is the founder of D.O.S. – Design Open Spaces s.r.l., a research-oriented design practice working across spatial interfaces, innovation processes and experimental cultural formats.

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He is an urban planner and researcher working at the intersection of urban regeneration, spatial governance, and lived experience in African cities. His work focuses on how everyday management practices, spatial design, and institutional arrangements shape perceptions of safety, comfort, and place attachment in inner-city and post-industrial environments. He has professional experience in precinct management, urban regeneration strategy, and development planning, with a particular emphasis on Global South contexts and incremental urban transformation. His research interests include multi-sensory urbanism, adaptive reuse, environmental perception, and the relationship between governance practices and spatial experience. His current work explores how non-visual and embodied dimensions of space influence regeneration outcomes, contributing to emerging debates on human-centred and regenerative approaches to urban design and management.

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Adjunct Professor of Transmedia Design and a Postdoctoral Researcher at the Department of Architecture, University of Florence, Italy. In 2023, she earned a PhD in Sustainability and Innovation for the Design of the Built Environment and Product System. She is a member of KYDE – Kids and Youth Design Lab, where her research focuses on product systems, interior and communication design for children and young people. She has been involved in several national and international research projects addressing interior design, product innovation, and design for emergency contexts. Her research interests include multisensory design, sustainable design and human-centered approaches to the design of products, interiors, and learning environments

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Hannah Moriarty

Interior designer and researcher who graduated from RMIT University with a Bachelor of Design (Interior) in 2013. She has since contributed to the RMIT Interior Design program as a sessional lecturer and researcher, specialising in ecological interiors, accessibility, exhibition design, and visual communication, while also contributing to neurodivergent design research. Hannah practises as an interior designer developing interior and architectural concepts informed by a background in wellness and community-led projects. Her work is shaped by a focus on accessibility, inclusive environments, and user-focused spatial outcomes, alongside leading diagrammatic and visual research methods for co-design processes and longitudinal studies.

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Lucia Ratti

Designer and Ph.D. candidate at the Design Department of Politecnico di Milano, her research explores the environmental responsibility of design across multiple domains, including urban biodiversity, circular exhibition design, and design for the energy transition. Her doctoral research focuses on the phenomenon of plant blindness, investigating how design can counteract it and foster plant awareness through situated practices in urban public spaces. Since 2019, she has been an

assistant in didactic activities in the Interior Design Bachelor's Degree of Politecnico's School of Design, and in 2020 she started working with the association Repubblica del Design, where she has taken care of the design and implementation of participatory design-didactic workshops, with partners such as the Municipality of Milan, Milan Triennale, and SOUX school of architecture for children.

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Alastair Reed

He holds a PhD in Forest Ecology and is a lecturer at the Royal Melbourne Institute of Technology (RMIT) and Melbourne Polytechnic. He brings over two decades of experience in higher education course design, working across interdisciplinary programs that connect environmental systems, design, and applied sciences.

His research spans forest genetics, viticulture, and data-informed analyses of environmental and socio-economic systems, including work on power imbalances within commercial structures. His current work focuses on multisensory design and more-than-human approaches, exploring how ecological systems thinking can inform spatial practice and support the development of responsive, relational environments.

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Dina Riccò

Associate Professor at the Department of Design (Politecnico di Milano). A graduate of architecture and with a PhD in Industrial Design, her main subject of study is applied synaesthesia to design and multimedia, communicative accessibility in audio-video and museums. Amongst her key publications: books entitled *Sinestesie per il design* (Etas, Milan, 1999), *Sentire il design* (Carocci, Rome, 2008), the book *Synaesthesia: Theoretical, artistic and Scientific Foundation* (with M. J. de Córdoba, Sean A. Day et al., ArteCittà, Granada, 2014, Spanish ed. 2012). She is the author of over 130 publications in books, journals, and national and international conferences, including the recent curations of the books *Accessibilità museale* (FrancoAngeli, 2023, Selected ADI Index 2024) and *Accessibilità comunicativa* (with M.C. Andriello; Rai Libri, 2024).

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Massimo Schinco

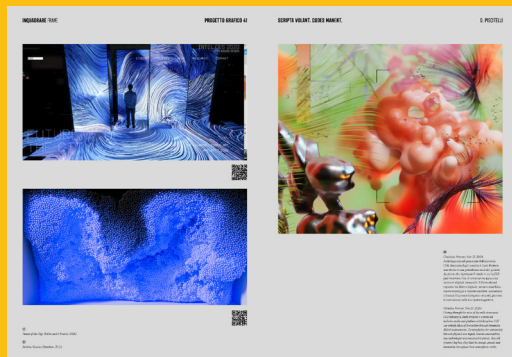
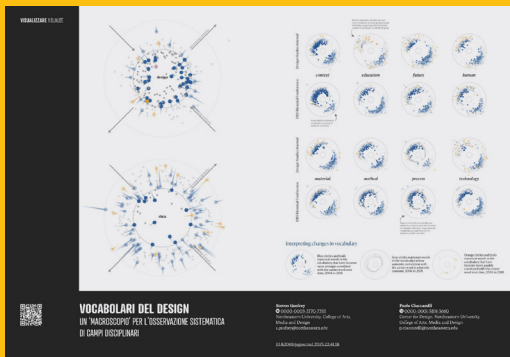
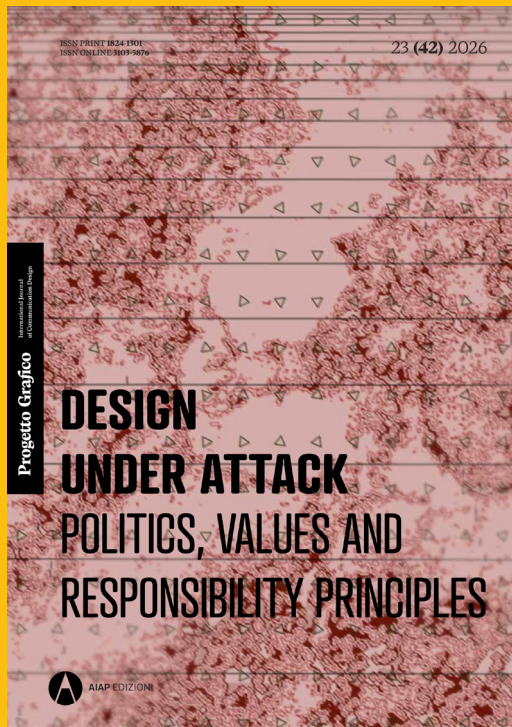
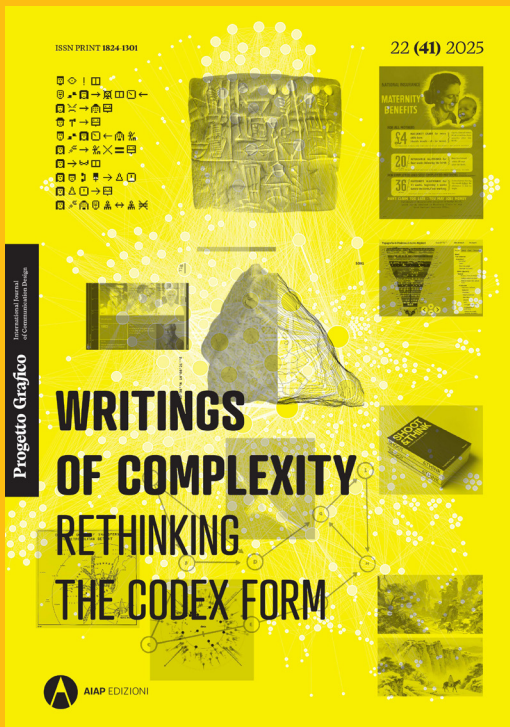
Psychologist and psychotherapist. He teaches Systemic Relational Psychotherapy in the Centro Studi Eteropoiesi, Turin, Italy. He is Adjunct Professor in the Department of Design, Milan Politecnico, Italy. His works focus on the bridge between oneiric thought and project creativity

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He is an architect and PhD Candidate in Design at Santa Catarina State University (Universidade do Estado de Santa Catarina), and a visiting researcher at the Politecnico di Milano. His research focuses on experience design, with particular attention to multisensory and cross-modal experience, sensory branding, and material agency in interior, retail, and phygital environments.

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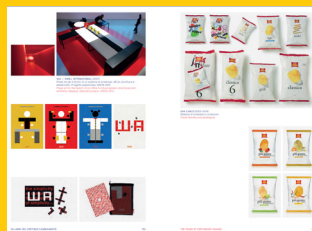
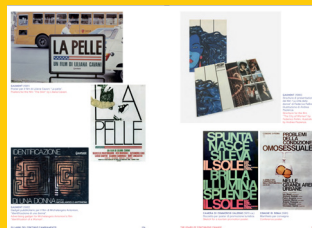
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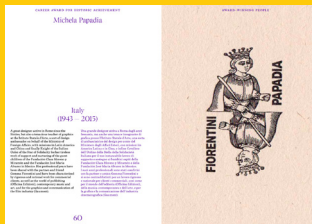
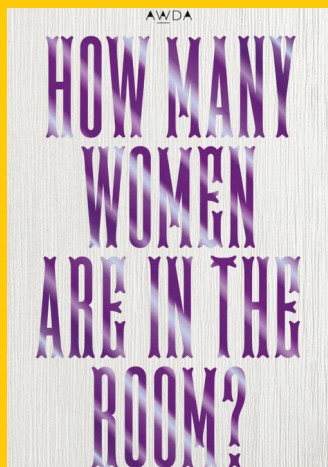
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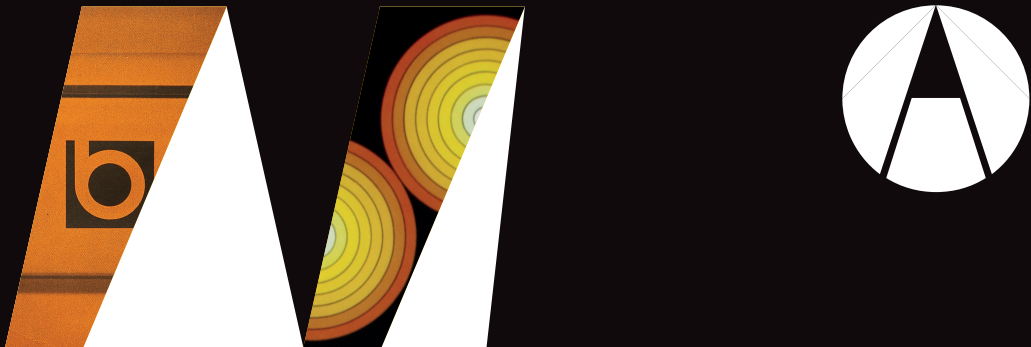
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The new AIAP CDPG digital platform is a project funded by the European Union – Next Generation EU within the framework of the PNRR (National Recovery and Resilience Plan) in accordance with Directorial Decree No. 385 dated 19/10/2022 – Sub-investment 3.3.2 – Support to cultural and creative sectors for innovation and digital transition. Project Ref. No. TOCC 0001515, COR 15905620, CUP C87I23000580008.



**Co-funded by
the European Union**



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PAD. Pages on Arts and Design

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

#30, Vol. 19, June 2026

www.padjournal.net



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