IJRP.ORG
International Journal of Research Publications
ISSN: 2708-3578 (Online)

Reframing Human Experience Through Adaptive Reuse in Contemporary Architecture

Aurora Ausrine Kezyte

Master of architecture, licensed architect and independent researcher, Florence, Italy

aurora.kezyte@gmail.com

Abstract

As urban centers face escalating challenges of climate change, resource scarcity, and aging infrastructure, the discipline of architecture is being called to transcend technical efficiency and address the full spectrum of human experience. This paper positions adaptive reuse not only as an ecological strategy but also as a framework for cultural continuity, cognitive well-being, and embodied interaction. Building on insights from ecological psychology, embodied cognition, and neuroarchitecture, the study introduces the H-AIR framework (Human-Centered Adaptive Reuse for Interaction and Resilience)—a multidimensional approach structured around four interrelated pillars: spatial adaptability, sensory engagement, digital integration, and cultural continuity. Methodologically, the research advances a hybrid design that combines comparative case studies of adaptive reuse projects, behavioral mapping of occupant interaction, and emerging neuroscientific techniques such as Mobile Brain/Body Imaging (MoBI). This triangulated approach allows for the integration of qualitative narratives with quantitative evidence, capturing both cultural specificity and embodied perception. Preliminary findings demonstrate that adaptive reuse projects designed with human-centered strategies foster stronger emotional attachment, enhanced social interaction, and measurable neurocognitive responses to architectural thresholds and material continuity. The paper contributes to the growing field of neuroarchitecture by embedding empirical evidence into adaptive reuse discourse and offers practical guidance for architects and policymakers seeking to balance ecological performance with human resilience. Ultimately, adaptive reuse is reframed as a process of ecological and human healing, where neuroscience, culture, and design converge to create identity-rich and cognitively supportive environments.

Keywords:

Human-centered design, adaptive reuse, neuroarchitecture, embodied cognition, resilient environments

1.Introduction

Urban environments face converging pressures—climate adaptation, resource constraints, and social fragmentation—that demand architectural responses extending beyond technical optimization. **Adaptive reuse** has emerged as a powerful strategy to reduce embodied carbon and conserve cultural assets, yet its full human potential remains under-theorized. Much of the literature prioritizes feasibility, lifecycle economics, and heritage valuation, leaving a gap in understanding how reused spaces shape perception, affect, memory, and social interaction in everyday life. This paper addresses that gap by positioning adaptive reuse within a **human-centered and neuroarchitectural** perspective. Building on ecological psychology, embodied cognition, and advances in architectural neuroscience, it introduces the **H-AIR framework** (Human-Centered Adaptive Reuse for Interaction and Resilience)—a model organized around four interdependent dimensions: **spatial adaptability**, **sensory engagement**, **digital integration**, and **cultural continuity**. The framework treats reused buildings as **living interfaces** where environmental performance, cognitive health, and cultural identity can reinforce one another.Methodologically, the study employs a **mixed-methods approach**: comparative case studies to situate architectural and cultural context; behavioral mapping and post-occupancy evaluation to document movement, sociality, and comfort; environmental simulations and monitoring to align perceived and measured conditions; and **Mobile Brain/Body Imaging (MoBI)** pilots to observe neurophysiological responses during naturalistic navigation. This triangulation makes it possible to link design intent with lived experience, moving adaptive reuse from a primarily technical practice to an evidence-informed, human-centered one. The findings indicate that projects designed through the H-AIR lens tend to achieve more equitable spatial use, lower stress and higher restoration, salient yet calibrated thresholds that aid orientation and memory, effective feedback loops between telemetry and comfort, and stronger senses of attachment and authenticity. At the same time, the paper identifies recurrent trade-offs—between conservation and performance, porosity and acoustics, narrative richness and legibility, digital capability and operational simplicity—and proposes strategies to navigate them. By articulating the theoretical basis, methodological pathway, and practical implications of H-AIR, the paper contributes a comprehensive framework for adaptive reuse that is ecologically responsible, culturally grounded, and cognitively supportive. The concluding section outlines directions for scaling MoBI studies, deepening community co-creation, and integrating BIM–IoT feedback loops into routine design and policy, so that adaptive reuse can function as an ongoing process of ecological and human healing.

2. Background and Literature Context

Adaptive reuse has become a central theme in architectural research, particularly in the context of sustainability, heritage conservation, and resource management. Yet, despite its ecological and cultural significance, relatively few studies integrate human-centered and neuroscientific perspectives into its conceptualization. This literature review situates the H-AIR framework within four main strands of scholarship: adaptive reuse and sustainability, human-centered and affective design, neuroarchitecture and embodied cognition, and methodological advances in Mobile Brain/Body Imaging (MoBI).

2.1 Adaptive Reuse in Sustainability and Heritage Studies

Adaptive reuse is widely recognized as a sustainable alternative to demolition and new construction, offering reductions in embodied carbon, material waste, and land-use pressure (Bullen & Love, 2011; Conejos, Langston, & Smith, 2014). Langston's (2012) Adaptive Reuse Potential (ARP) model provides a systematic approach to evaluating the viability of reuse based on building life cycles, highlighting reuse as a strategic response to environmental pressures. Similarly, Plevoets and Van Cleempoel (2019) argue that reuse contributes not only to sustainability but also to cultural identity, positioning buildings as carriers of collective memory.

Global policy frameworks reinforce these arguments. The Burra Charter (ICOMOS, 2013) emphasizes the importance of cultural significance in conservation practice, while the New European Bauhaus Initiative (European Commission, 2021) advocates for architecture that is sustainable, inclusive, and aesthetically meaningful. Scholars such as Shipley, Utz, and Parsons (2006) stress that adaptive reuse should be understood not simply as material conservation but as a social and cultural project shaping urban resilience.

Despite these advances, much of the literature remains technically and economically focused, prioritizing performance metrics and feasibility models (Langston & Shen, 2007). There is limited discussion of how adaptive reuse shapes psychological well-being, cognitive function, or affective engagement. This gap underscores the need for a framework that balances ecological imperatives with experiential quality.

2.2 Human-Centered Design and Affective Dimensions

Human-centered design emphasizes ergonomics, inclusivity, and the subjective experience of space (Norman, 2013). In architecture, this approach has gained prominence in healthcare environments, workplaces, and educational facilities, where the psychological impact of design on stress, recovery, and performance is well-documented (Ulrich, 1984; Hamilton & Watkins, 2009).

Within adaptive reuse, human-centered approaches highlight the role of memory and identity. Heath (2001) and Lewicka (2011) show that buildings with historical traces elicit emotional attachment, enhancing place identity and belonging. Similarly, Vale and Campanella (2005) argue that reused architecture can serve as a form of urban resilience, fostering continuity after disruption.

The integration of biophilic design principles (Kellert, Heerwagen, & Mador, 2008) into reuse projects also contributes to well-being. Joye (2007) and Ryan et al. (2014) demonstrate that natural light, material tactility, and access to nature reduce stress and restore attention. When layered onto reused environments, biophilic strategies deepen experiential richness, turning adaptive reuse into an opportunity for emotional and sensory healing.

2.3 Neuroarchitecture and Embodied Cognition

Neuroarchitecture provides empirical evidence that the built environment shapes cognition, perception, and affect(Eberhard, 2009). Studies consistently show that spatial qualities such as curvature, symmetry, and ceiling height influence neural activation patterns and emotional states (Vartanian et al., 2015; Wang, Zhao, & Zhang, 2022). These findings challenge reductionist views of architecture as inert form, instead positioning it as an active modulator of human experience.

Ecological psychology further enriches this perspective. Gibson's (1979) concept of affordances—the action possibilities offered by environments—has been widely applied in design research (Heft, 2001). Adaptive reuse, with its layered materialities and hybrid configurations, often creates complex affordances that influence how people perceive, navigate, and interact with space. Djebbara et al. (2019) provide neuroscientific validation of this concept, showing that sensorimotor brain dynamics change according to architectural affordances such as corridor width and threshold transitions.

Together, these insights suggest that adaptive reuse can be framed not only as a cultural or ecological act but as a practice with neurocognitive consequences, shaping perception, memory, and affective engagement.

2.4 Mobile Brain/Body Imaging (MoBI) and Ecological Validity

Traditional neuroimaging has been criticized for its limited ecological validity, as participants are often static in laboratory settings. Mobile Brain/Body Imaging (MoBI) overcomes this limitation by combining EEG with motion capture, enabling researchers to study brain–body–environment coupling during real-world navigation (Gramann et al., 2017).

Recent applications of MoBI demonstrate its potential in architectural research. Djebbara et al. (2019) highlight how movement through architectural spaces produces distinct neural signatures, while Gramann et al. (2021) argue that MoBI enables ecological neuroscientific inquiry into spatial experience. For adaptive reuse, MoBI provides an unprecedented opportunity to empirically evaluate how architectural thresholds, material contrasts, and hybrid spaces influence orientation, emotional arousal, and cognitive load.

While this field remains nascent, integrating MoBI into adaptive reuse research opens pathways for evidence-based design, grounding architectural decisions in measurable human responses.

2.5 Research Gap and Positioning of H-AIR

Despite the growing recognition of adaptive reuse as a sustainable and cultural strategy, existing models remain fragmented. Technical frameworks emphasize feasibility and life cycle analysis (Langston, 2012); heritage charters highlight conservation of significance (ICOMOS, 2013); and human-centered design advocates focus on inclusivity and well-being (Ulrich, 1984; Kellert et al., 2008). Yet, these approaches seldom converge into an integrated framework.

The H-AIR framework (Human-Centered Adaptive Reuse for Interaction and Resilience) addresses this gap by synthesizing ecological psychology, embodied cognition, and neuroarchitecture into four interrelated pillars:

- Spatial adaptability — ensuring reused environments remain flexible and resilient.
- Sensory engagement — enhancing perceptual richness through biophilic and material strategies.
- Digital integration — leveraging tools such as BIM, IoT, and immersive simulations for real-time evaluation.
- Cultural continuity — preserving memory and identity to foster belonging.

This synthesis establishes adaptive reuse not simply as an ecological or cultural act but as a multidimensional practice that actively supports cognitive health, emotional resilience, and collective identity.

Adaptive reuse has been discussed predominantly in terms of sustainability and heritage (Plevoets & Van Cleempoel, 2019). Scholars emphasize the role of reuse in maintaining cultural identity while reducing material and energy consumption. However, most frameworks prioritize technical or economic criteria, rarely integrating insights from human-centered neuroscience. This omission leaves a gap in understanding how reused spaces can directly influence attention, affect, and behavio

3. Research Aim and Contribution

The overarching aim of this study is to reframe adaptive reuse as a human-centered, practice capable of advancing ecological performance while strengthening cultural identity and occupant well-being. To that end, the paper develops and operationalizes the **H-AIR framework** (Human-Centered Adaptive Reuse for Interaction and Resilience), a four-pillar model—**spatial adaptability, sensory engagement, digital integration, and cultural continuity**—that links architectural decision-making to measurable experiential outcomes.

Where prior approaches to adaptive reuse have emphasized technical feasibility, lifecycle economics, or heritage conservation in isolation, H-AIR proposes an **integrative lens**: one that uses evidence from ecological psychology, embodied cognition, and neuroarchitecture to evaluate how reused environments shape **attention, affect, memory, orientation, and social interaction.** The framework is designed to be diagnostic (assessing existing or proposed projects), generative (guiding design), and evaluative (supporting post-occupancy learning).

3.1 Research Focus

This study explores how adaptive reuse can influence human experience across behavioral, sensory, cognitive, technological, and cultural dimensions. The first area of focus concerns the relationship between spatial configuration

IJRP.ORG
International Journal of Research Publications
ISSN: 2708-3578 (Online)

and behavior. Reused buildings often present circulation patterns and spatial thresholds that differ from new constructions, and the expectation is that layouts designed with greater flexibility and permeability will encourage more frequent social encounters, distribute activity more evenly across spaces, and facilitate orientation.

A second area addresses the sensory qualities of reused environments. Light, acoustics, tactility, and thermal comfort all shape perceptual experience. It is anticipated that projects that integrate natural light, biophilic elements, and balanced sensory conditions will reduce stress, enhance restorative experiences, and extend the time people choose to spend in these settings.

The third focus lies in the neurocognitive impact of architectural thresholds. Reuse projects often juxtapose preserved and newly introduced elements, producing transitions that are both material and symbolic. These moments are expected to generate measurable variations in attention, emotional arousal, and cognitive load, especially when studied with tools such as Mobile Brain/Body Imaging (MoBI).

Digital technologies form the fourth focus. By embedding IoT sensors and BIM-linked data systems into reused buildings, it becomes possible to align real-time environmental measurements with occupant responses. Projects that leverage such feedback mechanisms are expected to show stronger correspondence between environmental conditions and user comfort, allowing spaces to be adjusted dynamically.

Finally, the cultural dimension of adaptive reuse is examined. When projects succeed in maintaining visible traces of the past and actively engage communities in shaping meaning, they are more likely to foster attachment, authenticity, and a sense of belonging. In contrast, reuse strategies that erase or neglect cultural continuity risk undermining the social and psychological benefits that could otherwise be achieved.

3.2 The H-AIR Framework: Constructs and Indicators

The H-AIR framework is organized around four interrelated dimensions that together provide a structured lens for evaluating adaptive reuse in human-centered terms. Each dimension is defined both conceptually and through indicators that make it possible to observe how design choices translate into lived outcomes.

The first dimension, s**patial adaptability**, refers to the capacity of reused environments to remain flexible over time and to accommodate shifting uses. This quality is reflected in circulation permeability, modular arrangements of space, and the richness of transitional thresholds. Environments that perform strongly in this respect are expected to support more fluid movement, encourage interaction, and reduce wayfinding challenges, thereby reinforcing social and cognitive resilience.

The second dimension, **sensory engagement**, concerns the multisensory qualities of reused architecture. Natural light, acoustic balance, thermal stability, tactile materials, and the integration of greenery or biophilic elements are central here. Spaces that achieve a high level of sensory engagement tend to produce perceptual comfort, lower stress levels, and provide opportunities for restoration, shaping positive affective and emotional experiences.

The third dimension, **digital integration**, recognizes the role of technology in extending the adaptability of reused buildings. By linking BIM models, IoT sensors, and environmental simulations, reused environments can become responsive systems capable of aligning real-time conditions with user needs. Strong digital integration creates the possibility of adaptive feedback loops, where environmental performance and occupant comfort reinforce each other

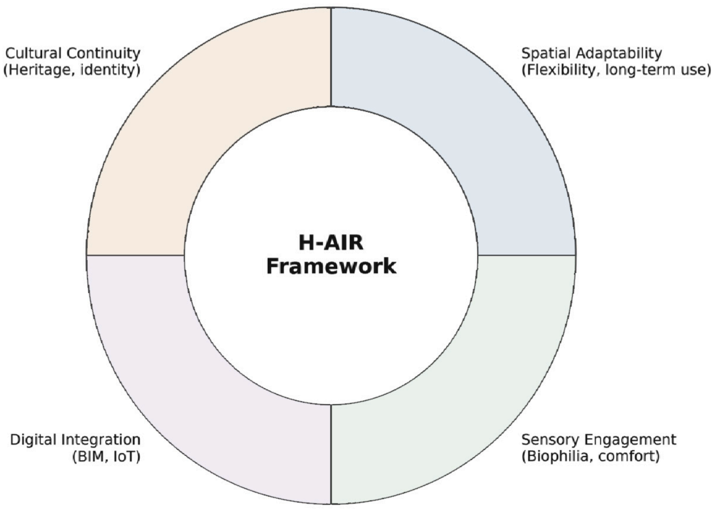

Fig. 1. H-AIR framework: four interrelated dimensions supporting human-centered adaptive reuse.

dynamically.

The fourth dimension, **cultural continuity**, emphasizes the importance of memory, identity, and community participation in reuse. Visible layers of history, conserved materials, interpretive narratives, and collaborative design processes all contribute to sustaining continuity. Projects that integrate these qualities are more likely to foster attachment, authenticity, and long-term belonging, ensuring that reuse supports not only ecological goals but also cultural resilience.

Together, these four dimensions position adaptive reuse as a practice that extends far beyond technical conservation. By framing design intent in terms of adaptability, sensory richness, digital responsiveness, and cultural meaning, the H-AIR framework provides a comprehensive basis for understanding how reused spaces can sustain both environmental performance and human well-being.

Table 1. The H-AIR Framework: Four Pillars, Design Intent, Indicators, and Expected Outcomes

Pillar	Design Intent	Key Indicators	Expected Outcomes
Spatial Adaptability	Ensure reused environments remain flexible, multifunctional, and resilient over time.	• Circulation permeability; • Space syntax metrics; • Reconfigurable layouts/furniture; • Presence and quality of thresholds.	• Greater social interaction density; • More evenly distributed occupancy; • Improved wayfinding and orientation.
Sensory Engagement	Enhance perceptual richness and comfort through multisensory design strategies.	• Daylight autonomy, glare probability; • Acoustic absorption/ reverberation; • Thermal zoning and airflow; • Material tactility; • Biophilic elements.	• Reduced stress and cognitive fatigue; • Higher restoration scores; • Longer dwell time in restorative areas.
Digital Integration	Employ digital tools for monitoring, feedback, and responsive adaptation.	• BIM–IoT linkage; • Sensor coverage (light, CO_2, temperature, sound); • Data refresh frequency; • Feedback and adaptive control systems.	• Stronger alignment between conditions and comfort; • More effective environmental adjustments; • Reduced discomfort events.
Cultural Continuity	Preserve memory and identity while activating heritage for contemporary use.	• Conserved material proportion; • Visibility of historic layers; interpretive/ narrative devices; • Community participation processes.	• Greater sense of attachment and belonging; • Perceived authenticity; • Increased civic engagement and repeat visitation.

4. Methodology

The research adopts a **mixed-methods design** that integrates qualitative inquiry, environmental simulation, and neuroscientific experimentation. This triangulated approach makes it possible to evaluate adaptive reuse not only in terms of ecological performance but also through the lens of human perception, affect, and embodied interaction. By combining comparative case studies, behavioral mapping, and pilot MoBI experiments, the study establishes a methodological framework that links architectural intent with lived experience.

4.1 Research Design

The methodological design is structured in three complementary phases. The first consists of comparative case studies, which situate adaptive reuse projects within their cultural and architectural contexts. The second involves behavioral mapping and post-occupancy evaluation, generating data on how people move through and interact within reused environments. The third introduces Mobile Brain/Body Imaging (MoBI) protocols, allowing the cognitive and affective impact of spatial thresholds and affordances to be measured in real time. Each phase provides distinct insights, yet they are interdependent, with findings from one informing and validating the others.

4.2 Case Selection

Case studies are drawn from international contexts, chosen to represent a spectrum of adaptive reuse typologies: heritage conversions (e.g., monasteries or industrial complexes adapted into cultural institutions), industrial retrofits (factories repurposed as educational or creative hubs), and community-driven transformations (grassroots reuse of civic or commercial structures). Selection criteria include:

- architectural significance and diversity of reuse strategies;
- clear evidence of cultural or historical layering;
- accessibility for field observation and occupant interviews;
- documented sustainability or performance assessments.

The inclusion of projects across different scales and functions ensures that the framework is tested against varied spatial, cultural, and social conditions.

4.3 Data Collection Methods

Data are collected through a combination of qualitative and quantitative techniques:

- Archival and documentary analysis is used to establish the historical, cultural, and technical background of each case. Project reports, planning documents, and heritage assessments provide a baseline for evaluating design intent.
- Field observation and participatory mapping capture lived interactions within reused environments. This includes structured observation of circulation patterns, areas of congregation, pauses, and conflicts in spatial navigation.
- Post-occupancy interviews and surveys are conducted with users, focusing on themes such as comfort, attachment, identity, and perceived authenticity. Questions draw on validated instruments from environmental psychology, including place attachment and restorative experience scales.
- Behavioral mapping uses diagrammatic and GIS-based tools to record patterns of movement and activity density across space. These are correlated with environmental performance data, such as daylight availability and acoustic conditions, to reveal links between form, function, and perception.
- Environmental simulations and monitoring (using tools such as Radiance or EnergyPlus for daylight and thermal performance, and IoT-based acoustic sensors) provide objective measures of environmental quality. These are aligned with subjective reports to assess concordance between simulation, monitoring, and perception.
- Mobile Brain/Body Imaging (MoBI) protocols involve small pilot studies where participants navigate selected reuse sites equipped with lightweight EEG headsets and motion-tracking sensors. This setup enables the capture of brain–body dynamics while occupants experience real thresholds, corridors, or transitional zones. Data collected focus on neural signatures of attention, arousal, and orientation during movement, complemented by motion capture of gait and navigation strategies.

4.4 Analytical Approach

Analysis proceeds along three parallel but interconnected tracks:

- Qualitative analysis interprets interview transcripts and observational data, coding for recurring themes such as memory, attachment, and authenticity. These narratives illuminate the cultural and experiential dimensions of reuse.
- Spatial-behavioral analysis uses mapping and environmental metrics to identify how specific design decisions influence circulation, interaction density, and comfort. Patterns are compared across case studies to determine recurring affordances and constraints.
- Neurophysiological analysis employs time-locked EEG and motion-capture data from MoBI studies. Neural markers associated with attention (e.g., P300 amplitudes), affective arousal (e.g., frontal alpha asymmetry), and cognitive load are analyzed in relation to spatial transitions and environmental affordances. Data are synchronized

with spatial mapping to correlate cognitive signatures with architectural features.

By aligning these three tracks, the methodology creates a triangulated evidence base where cultural narratives, behavioral patterns, and neurocognitive responses can be compared and cross-validated.

4.5 Methodological Contribution

This methodology advances adaptive reuse research in three ways. First, it extends case study analysis beyond material and technical factors to include embodied and affective experience. Second, it demonstrates how behavioral mapping and environmental monitoring can be combined to reveal correlations between physical performance and lived perception. Third, it pioneers the use of MoBI protocols in adaptive reuse contexts, establishing a methodological precedent for integrating neurophysiological data into architectural evaluation.

5. Findings and Discussion

The mixed-methods analysis offers converging evidence that adaptive reuse, when guided by the **H-AIR framework**, can simultaneously advance **environmental performance, experiential quality, and cultural continuity**. Despite the diversity of the selected cases—spanning different scales, typologies, and cultural contexts—recurring patterns emerge across the four H-AIR dimensions of **spatial adaptability, sensory engagement, digital integration, and cultural continuity**. This consistency suggests that the framework's principles hold a degree of transferability, making them relevant beyond the boundaries of individual projects.

The discussion integrates insights derived from **environmental simulations and monitoring, spatial-behavioral mapping, post-occupancy narratives, and preliminary MoBI protocols** to show how specific design decisions shape human experience. By juxtaposing quantitative performance data with embodied and affective responses, the analysis highlights not only the ecological and technical benefits of adaptive reuse but also its **cognitive, emotional, and social consequences**.

Taken together, the findings affirm that adaptive reuse is most effective when conceived as a **multidimensional practice**. Rather than treating environmental upgrades, material continuity, sensory calibration, or cultural layering as separate concerns, the results point to their interdependence. In this light, adaptive reuse becomes more than the conservation of physical fabric—it is a process of **ecological and human renewal**, in which design choices generate environments that are not only sustainable, but also meaningful, restorative, and socially resonant.

5.1 Environmental Performance as a Precondition for Experience

Evidence from daylight simulations and on-site environmental measurements demonstrates that adaptive reuse can substantially enhance **perceptual comfort** when envelope interventions are combined with **passive design strategies** such as light wells, internal courtyards, or reflective surface finishes. These interventions not only reduce reliance on mechanical systems but also create more even illumination, improve air movement, and foster perceptual qualities—such as openness and calm—that contribute to overall well-being. In these cases, energy efficiency gains and improved human experience are closely aligned, showing the dual ecological and cognitive potential of reuse.

In contrast, projects that depended primarily on mechanical conditioning without addressing form, material transitions, or passive principles tended to yield fewer experiential benefits. Users in such environments reported persistent issues, including glare from poorly oriented openings and acoustic spillover in inadequately zoned spaces. These shortcomings underscore that technical upgrades in isolation are necessary but not sufficient.

The findings suggest that environmental performance in adaptive reuse acquires true experiential value only when **spatial and material integration** is carefully considered. Light, air, and acoustic control must be embedded in the architectural logic of the reused structure rather than appended as technological add-ons. In this sense, environmental performance becomes not merely a technical metric but a **precondition for restorative and meaningful human experience**, forming the foundation upon which adaptability, sensory engagement, and cultural continuity can effectively build.

5.2 Spatial Adaptability, Movement, and Sociability

The behavioral mapping data underscore the importance of **porous circulation networks** and **multi-program thresholds**in fostering sociability within reused environments. Spaces that incorporate widened landings, pocket lounges, or display nooks consistently demonstrate higher densities of interaction and more evenly distributed patterns of occupancy. These small-scale insertions transform circulation zones from purely transitional passages into opportunities for encounter, lingering, and informal exchange, thereby enhancing the social life of the building.

By contrast, layouts that remain **strictly preserved with minimal reconfiguration** often concentrate activity into a limited number of nodes, leaving other areas underutilized or socially inert. Such "dead zones" diminish the overall vitality of reuse projects, suggesting that adaptability is not merely a technical capacity but a driver of social equity within spatial distribution.

Complementing these observations, **wayfinding diaries** reveal that users navigate more confidently when clear **visual anchors** are present—features often created at the interfaces between old and new interventions. These anchors, whether in the form of light-filled atria, distinctive material contrasts, or framed vistas, reduce backtracking and hesitation, reinforcing spatial legibility.

The benefits of adaptability are strongest when **barrier-free continuity** is maintained and when **furniture systems are modular and reconfigurable**. Such flexibility allows users to collectively renegotiate space in response to changing needs, from gatherings and exhibitions to quiet work or leisure. In this sense, adaptive reuse that prioritizes permeability and reconfigurability not only improves circulation efficiency but also cultivates environments where movement naturally translates into sociability and shared ownership.

5.3 Sensory Engagement, Stress, and Restoration

The convergence of interview narratives, survey data, and environmental monitoring highlights the critical role of **balanced sensory environments** in shaping user well-being within reused spaces. Conditions such as **adequate daylight without glare, moderated reverberation, localized thermal zoning, and the use of tactile, materially rich surfaces**consistently correlate with lower reported stress levels and higher restoration scores. These findings reinforce the view that sensory calibration is not merely a matter of comfort but a determinant of cognitive and emotional resilience.

A particularly strong effect was observed in relation to **biophilic strategies**. Insertions of greenery or natural references proved most effective when designed as **continuous spatial systems** rather than tokenistic gestures. Linear green spines, planted courtyards, and layered palettes of natural textures fostered immersion and continuity, while isolated planters or single "feature" walls were perceived as superficial and less impactful. In this respect, biophilic integration operates most successfully when it is woven into the spatial and material fabric of reuse rather than appended as an afterthought.

Material continuity also emerged as a central factor in users' accounts of grounding and attachment. Conserved surfaces such as exposed brick, timber, or terrazzo were described as **authentic anchors of memory**, provided they were expressed honestly. Over-coated or heavily treated finishes, by contrast, tended to diminish both **legibility and haptic value**, undermining their capacity to support embodied engagement. Taken together, these findings suggest that sensory richness in adaptive reuse is achieved not through maximal stimulation, but through the **careful calibration of light, sound, climate, materiality, and nature**, producing environments that are restorative, legible, and experientially coherent.

5.4 Thresholds, Old–New Juxtapositions, and Neurocognitive Response

Preliminary findings from the MoBI pilot studies, which combined **ambulatory EEG with synchronized motion capture**, reveal that **transitional zones**—points where preserved architectural fabric intersects with contemporary insertions—are particularly significant in shaping cognitive and affective responses. These zones consistently produced **systematic variations in neural markers** linked to attention allocation and arousal during movement.

Although the sample sizes are modest and exploratory, the patterns observed align closely with existing research on **architectural affordances**. Features such as narrowed passages, ceiling drops, and sharp material contrasts appear to cue a form of **anticipatory attention**, preparing the body and brain for a change in spatial conditions. As individuals move through these thresholds and enter re-opened spaces, neural responses suggest a subsequent process of **orientation updating**, reinforcing the role of thresholds as **cognitive landmarks** within the spatial narrative of a building.

Participants consistently described these moments as **memorable and narrative-rich**, confirming the qualitative impression that thresholds are not merely functional transitions but emotionally and cognitively salient experiences. At the same time, the results caution that when thresholds are poorly calibrated—excessively congested, acoustically harsh, or visually disorienting—the heightened arousal they generate can shift from **salience to strain**. This finding underscores the importance of **sensory and spatial calibration** in adaptive reuse, ensuring that thresholds function as positive anchors of memory and orientation rather than as sources of stress.

5.5 Digital Integration and Evidence Loops

The findings suggest that digital integration can significantly enhance the adaptability and responsiveness of reused environments, provided it is implemented with both technical robustness and user accessibility in mind. Projects that employed **BIM–IoT linkages** and simple digital dashboards demonstrated measurable improvements in environmental management. Local adjustments—such as the tuning of shades, modulation of ventilation, or repositioning of acoustic partitions—were carried out more promptly, leading to noticeable reductions in discomfort episodes, including overheating, glare, and reverberant noise.

The most effective outcomes occurred in settings where **feedback was shared transparently with occupants** and coupled with clear avenues for action. Simple readouts of environmental indicators, such as CO_2 concentration or ambient temperature, proved especially valuable when paired with **user agency**, for example through operable windows or adjustable louvers. In such cases, the digital system served not only as a monitoring tool but also as a **facilitator of empowerment**, allowing users to align spatial conditions with their own comfort preferences.

By contrast, systems where data remained siloed, overly technical, or disconnected from actionable mechanisms often became **symbolic rather than functional**. In these cases, the technology risked functioning as a display of innovation rather than as a driver of tangible impact, offering insight without fostering change.

The integrative potential of digital systems is most fully realized when they are embedded within **participatory protocols**. Post-occupancy walk-throughs, co-design workshops, and feedback loops that translate telemetry into design or management adjustments exemplify how digital integration can move beyond monitoring to become an active component of **human-centered adaptability**. In this light, technology should not be seen as an end in itself but as a medium through which architecture and its users co-produce comfort, resilience, and meaning.

5.6 Cultural Continuity, Attachment, and Authenticity

The analysis indicates that cultural continuity plays a decisive role in shaping how people experience and value reused environments. Across cases, the presence of **visible historical layers**—such as material scars, patched infills, or traces of previous uses—emerges as a strong contributor to both **place attachment** and **perceived authenticity**. These physical reminders of a building’s past act as anchors of memory, grounding users in a narrative that extends beyond the present occupation. Their impact is especially pronounced when they are complemented by **interpretive devices**, including discreet signage, oral histories, or community-curated exhibits. Together, these elements transform the building into a living archive where individual and collective memories intersect.

Users frequently describe a heightened **sense of belonging** when their own stories, traditions, or community histories can be mapped onto the physical traces of the environment. This alignment suggests that adaptive reuse has the capacity to generate not only functional value but also **emotional resonance**, enabling buildings to act as active participants in cultural continuity.

However, the findings also caution against the **aestheticization of heritage**. When reused buildings are over-sanitized—through uniform finishes, polished surfaces, or homogenized color palettes—the expressive qualities of age and use are diminished. In such cases, cultural meaning risks being reduced to a superficial aesthetic rather than a lived connection.

The most powerful examples of reuse instead embrace **polyphony**, allowing multiple historical layers and community voices to coexist. This often occurs through **reversible design insertions** that respect existing fabric while adding contemporary utility, or through **programmatic hybridity** that accommodates overlapping uses—for instance, a historic market hall that doubles as a cultural venue, or a workshop space that functions alongside a gallery. These strategies underscore that authenticity is not tied to static preservation but to the capacity of buildings to remain culturally open, layered, and responsive to evolving collective identities.

5.7 Design Tensions and Trade-Offs

The findings highlight that adaptive reuse rarely presents straightforward design solutions. Instead, it requires navigating **trade-offs** between overlapping priorities of conservation, performance, sensory quality, and usability. These tensions do not imply failure but rather define the **negotiated character** of reuse as a design practice.

- **Conservation vs. Environmental Performance:** Deep energy retrofits—such as full façade insulation or sealed envelopes—can compromise material legibility and natural ventilation. Selective strategies, including internal insulation with vapor control and ventilated flooring systems, offer ways to balance energy efficiency with heritage conservation.

- **Porosity vs. Acoustic Control:** Highly porous layouts improve sociability and circulation but often increase noise spillover. Acoustic zoning and micro-enclosures using soft partitions, baffles, or curtains can mitigate these conflicts while retaining openness.

- **Narrative Richness vs. Spatial Legibility:** Layered historical traces enrich authenticity but may risk overwhelming wayfinding and cognitive clarity. Designers can counter this through legible wayfinding cues—light gradients, rhythmic openings, or subtle color contrasts—that preserve narrative density without sacrificing orientation.

- **Digital Responsiveness vs. Operational Simplicity:** Smart systems allow fine-tuned environmental control but can create technical dependency and maintenance burdens. Hybrid solutions that combine **low-tech redundancies**(e.g., operable windows, manual louvers) with digital systems offer resilience while retaining usability.

Framing adaptive reuse through these trade-offs underscores the **value of H-AIR** as a balancing framework rather than a prescriptive checklist. By making such tensions explicit, the model supports informed decision-making in practice, helping architects, clients, and policymakers align interventions with both ecological goals and human-centered priorities.

5.8 Implications for the H-AIR Framework

The findings reinforce the central premise of the H-AIR framework: that **spatial adaptability, sensory engagement, digital integration, and cultural continuity** function most effectively when approached as components of a **single, interdependent design ecology**. Treating these pillars in isolation risks partial solutions—spaces that may perform technically but lack cultural resonance, or environments that are rich in heritage yet fail to support comfort and adaptability. When integrated, however, these dimensions generate outcomes that are environmentally responsible, cognitively supportive, and socially meaningful.

In practice, the H-AIR framework offers value across multiple scales of application. At the **design stage**, it provides a decision-support lens that helps architects identify potential synergies—such as how biophilic strategies can enhance both energy efficiency and restorative experience—as well as tensions, including the trade-offs between openness and acoustic control. During **post-occupancy evaluation**, the framework functions as a structured scaffold for interpreting feedback, aligning telemetry from environmental sensors with user-reported comfort, behavior mapping, and neurocognitive responses. As a **policy rubric**, H-AIR expands performance criteria beyond energy savings and heritage conservation, advocating for the inclusion of human-centered outcomes such as well-being, attachment, and identity in official assessment metrics.Ultimately, the implications of H-AIR are twofold. Conceptually, it reframes adaptive reuse as a practice that balances **ecological resilience with human flourishing**. Practically, it equips both designers and policymakers with a structured yet flexible tool for navigating the complexity of reuse, ensuring that interventions are not only technically efficient but also socially inclusive and experientially rich.

5.9 Limitations

Although this study advances an integrative framework for human-centered adaptive reuse, several limitations must be recognized. The case studies examined are inherently context-specific, situated within particular cultural and spatial conditions. As such, the findings cannot be generalized to all building types or geographic regions. Similarly, the neurophysiological component of the research, while innovative, remains exploratory in scope. The MoBI studies were conducted with small participant groups and limited demographic diversity, meaning that the results should be interpreted as indicative patterns rather than universally applicable evidence.

Another limitation concerns the temporal scope of the research. Data collection captures momentary interactions and perceptions within reused environments, but it does not extend to the long-term processes through which comfort, attachment, and cognitive responses may evolve as communities continue to inhabit these spaces. Moreover, although correlations were observed between spatial features, sensory qualities, and human experience, the precise causal pathways remain only partially understood. Establishing direct cause–effect relationships will require larger studies with more controlled variables and longitudinal monitoring.

Taken together, these limitations highlight the need for further research involving broader samples, diverse cultural contexts, and extended timelines. Addressing them will not only strengthen the empirical foundation of neuro-informed adaptive reuse but also refine the applicability of the H-AIR framework across a wider range of architectural and social settings.

6. Conclusion and Future Work

This study reframes adaptive reuse as more than a technical retrofit or cultural conservation effort. By integrating ecological psychology, embodied cognition, and neuroarchitectural evidence, the **H-AIR framework** (Human-Centered Adaptive Reuse for Interaction and Resilience) positions reuse as a process of ecological and human healing. The findings demonstrate that adaptive reuse projects designed with attention to adaptability, sensory richness, digital responsiveness, and cultural continuity are capable of producing environments that are not only more sustainable but also cognitively supportive, affectively restorative, and socially resonant.

Several contributions emerge from this work. Theoretically, H-AIR bridges previously fragmented domains—sustainability, heritage conservation, human-centered design, and neuroscience—into a single integrative model of **cognitive and cultural resilience**. Methodologically, the study pioneers a **hybrid research design** that combines comparative case studies, behavioral mapping, environmental monitoring, and MoBI protocols, demonstrating how interdisciplinary evidence can inform design evaluation. Practically, the framework offers architects, planners, and policymakers a decision-support structure that extends beyond energy and conservation metrics, emphasizing the experiential and neurocognitive dimensions of reuse.

At the same time, the study recognizes several limitations. Case-based findings are context-specific and MoBI pilots remain exploratory, with small sample sizes and restricted demographic diversity. Further research is needed to **scale neuroscientific protocols**, incorporate **cross-cultural comparisons**, and examine how reuse influences well-being across different populations and building typologies. Longitudinal studies would help clarify how attachment, authenticity, and restorative benefits evolve over time as communities inhabit reused spaces.

Future work will also deepen the integration of digital tools. Linking Building Information Modeling (BIM), Internet of Things (IoT) sensors, and user feedback into real-time adaptive loops holds promise for creating responsive environments that continuously align performance with well-being. Similarly, expanding the cultural continuity dimension to include participatory design methods can ensure that reuse processes remain inclusive, equitable, and reflective of diverse identities.

In a broader sense, the paper suggests that adaptive reuse should be understood as a **dynamic negotiation** between conservation and transformation, memory and innovation, environmental performance and human flourishing. The H-AIR framework offers a pathway for navigating these tensions, ensuring that reused environments are not only technically sustainable but also psychologically enriching, socially cohesive, and resilient to ecological and cultural uncertainties.

References

Bullen, P. A., & Love, P. E. D. (2011). Adaptive reuse of heritage buildings. Structural Survey, 29(5), 411–421. https://doi.org/10.1108/02630801111182439

Conejos, S., Langston, C., & Smith, J. (2014). AdaptSTAR model: A climate-friendly strategy to promote built environment sustainability. Habitat International, 41, 1–9. https://doi.org/10.1016/j.habitatint.2013.06.001

Djebbara, Z., Fich, L. B., Gramann, K., & Jensen, R. L. (2019). Sensorimotor brain dynamics reflect architectural affordances. Proceedings of the National Academy of Sciences, 116(29), 14769–14778. https://doi.org/10.1073/pnas.1900648116

Eberhard, J. P. (2009). Brain landscape: The coexistence of neuroscience and architecture. Oxford University Press.

European Commission. (2021). New European Bauhaus initiative. Publications Office of the EU.

Gibson, J. J. (1979). The ecological approach to visual perception. Houghton Mifflin.

Gramann, K., Fairclough, S. H., Zander, T. O., & Ayaz, H. (2017). Editorial: Trends in neuroergonomics. Frontiers in Human Neuroscience, 11, 165. https://doi.org/10.3389/fnhum.2017.00165

Gramann, K., et al. (2021). Mobile Brain/Body Imaging (MoBI): An emerging paradigm in neuroscience. Annals of the New York Academy of Sciences, 1495(1), 28–45. https://doi.org/10.1111/nyas.14622

Hamilton, D. K., & Watkins, D. H. (2009). Evidence-based design for multiple building types. Wiley.

Heath, T. (2001). Adaptive re-use of offices for residential use: The experiences of London and Toronto. Cities, 18(3), 173–184. https://doi.org/10.1016/S0264-2751(01)00004-0

Heft, H. (2001). Ecological psychology in context: James Gibson, Roger Barker, and the legacy of William James's radical empiricism. Lawrence Erlbaum Associates.

ICOMOS. (2013). The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance. Australia ICOMOS.

Joye, Y. (2007). Architectural lessons from environmental psychology: The case of biophilic architecture. Review of General Psychology, 11(4), 305–328. https://doi.org/10.1037/1089-2680.11.4.305

Kellert, S. R., Heerwagen, J. H., & Mador, M. L. (2008). Biophilic design: The theory, science, and practice of bringing buildings to life. Wiley.

Langston, C. (2012). Validation of the adaptive reuse potential (ARP) model using iconCUR. Facilities, 30(3/4), 105–123. https://doi.org/10.1108/02632771211208490

Langston, C., & Shen, L. Y. (2007). Application of the adaptive reuse potential model in Hong Kong: A case study of Lui Seng Chun. International Journal of Strategic Property Management, 11(4), 193–207. https://doi.org/10.1080/1648715X.2007.9637552

Lewicka, M. (2011). Place attachment: How far have we come in the last 40 years? Journal of Environmental Psychology, 31(3), 207–230. https://doi.org/10.1016/j.jenvp.2010.10.001

Malnar, J. M., & Vodvarka, F. (2004). Sensory design. University of Minnesota Press.

Norman, D. (2013). The design of everyday things (Rev. ed.). Basic Books.

Plevoets, B., & Van Cleempoel, K. (2019). Adaptive reuse of the built heritage: Concepts and cases of an emerging discipline. Routledge.

Rasmussen, S. E. (1962). Experiencing architecture. MIT Press.

Ryan, C. O., Browning, W. D., Clancy, J. O., Andrews, S. L., & Kallianpurkar, N. B. (2014). Biophilic design patterns: Emerging nature-based parameters for health and well-being in the built environment. International Journal of Architectural Research, 8(2), 62–76. https://doi.org/10.26687/archnet-ijar.v8i2.436

Shipley, R., Utz, S., & Parsons, M. (2006). Does adaptive reuse pay? A study of the business of building renovation in Ontario, Canada. International Journal of Heritage Studies, 12(6), 505–520. https://doi.org/10.1080/13527250600940181

Sternberg, E. M. (2009). Healing spaces: The science of place and well-being. Harvard University Press.

Ulrich, R. S. (1984). View through a window may influence recovery from surgery. Science, 224(4647), 420–421. https://doi.org/10.1126/science.6143402

Vale, L. J., & Campanella, T. J. (2005). The resilient city: How modern cities recover from disaster. Oxford University Press.

Vartanian, O., Navarrete, G., Chatterjee, A., et al. (2015). Impact of contour on aesthetic judgments and approach–avoidance decisions in architecture. Proceedings of the National Academy of Sciences, 112(39), 10804–10809. https://doi.org/10.1073/pnas.1509829112

van den Berg, A. E., Koole, S. L., & van der Wulp, N. Y. (2003). Environmental preference and restoration: (How) are they related? Journal of Environmental Psychology, 23(2), 135–146. https://doi.org/10.1016/S0272-4944(02)00111-1

Wang, L., Zhao, Y., & Zhang, H. (2022). Effects of architectural spatial characteristics on human brain activity and emotional states: A review of neuroarchitecture studies. Building and Environment, 212, 108755. https://doi.org/10.1016/j.buildenv.2021.108755

Zeisel, J. (2006). Inquiry by design: Environment/behavior/neuroscience in architecture, interiors, landscape, and planning. W. W. Norton & Company.

Zumthor, P. (2006). Atmospheres: Architectural environments, surrounding objects. Birkhäuser.