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Editorial: Re-imagining mediated human building interaction and sensory environments

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Editorial on the Research Topic
Re-imagining mediated human building interaction and sensory environments

Introduction

We are entering an era of machine intelligence, which will potentially transform every aspect of life. Emerging technologies such as the next generation of AI, extended reality XR, and embodied robotics are reshaping how we interact with the world around us (Morel and Bier, 2023). These advancements are becoming integral to the design, construction, and experience of buildings (Figure 1). They hold the potential for greater efficiency, sustainability, and user interactivity, and may make buildings more adaptive to human needs. However, they also raise important questions about the evolving relationship between humans, non-human agents, and these new environments.

Building upon existing frameworks (Alavi et al., 2019; Becerik-Gerber et al., 2022), this Research Topic investigates the next wave of Human-Building Interaction (HBI) addressing the interplay between human experience and intelligent environments. It, specifically, highlights the emerging hybrid agency that shapes interactions and potentially creates new paradigms. In this context, HBI presents new challenges and opportunities across interactional, technological, cognitive, spatial, social, and environmental dimensions.

The articles in this Research Topic are categorized into four types of contributions: **Theoretical**, **Review and Concepts**, **Methodological, Empirical and Applied Research**. Based on the integration of cross-disciplinary methodologies that draw on knowledge from architecture, human-computer interaction, interaction design, design computing, artificial intelligence and human interfaces, cognitive science/neuroscience, and the health and wellbeing of humans and non-human actors, they address multiple dimensions, including:

FIGURE 1
A design proposal by UN Studio, featuring the floor as a digital display with dynamicinformation. Source, photo of the presentation by UN Studio keynote at Media Architecture Biennale 2018 in Beijing (source: by the lead author).

- **Phenomenology and extended agency**: theory was used to understand how subjective human experiences of space are mediated by sensory inputs.
- **Ecological interaction**: it incorporated non-human actors, such as robotics or plants, as active participants in office spaces, demonstrating how technology can mediate and facilitate a more ecological, symbiotic relationship between humans, more than human, technology, and the environment, thereby expanding the scope of human-building interaction beyond traditional models.
- **Technological integration**: advancements in AI, new materials, robotics, and neuroarchitecture provided new tools for studying and designing human-building interactions that extend beyond traditional paradigms.
- **Mixed methods (quantitative and qualitative analysis) and prototyping in the real world**: several papers proposed combining ethnographic methods, prototyping, and data analysis using either conventional or advanced methods, such as machine learning and robotics, to understand mediated experiences in the real world.

These contributions are outlined below (Figure 2):

Theoretical: Kirsh investigates architectural atmosphere, which arises from various perceptual factors such as light, texture, geometry, acoustics, and smell. These non-linear interactions influence the quality of a space and emotions, creating a distinctive mood that shapes the experience and interaction of its inhabitants. The paper contrasts two approaches to studying atmosphere: an externalist view, which treats atmosphere as a measurable, causal property of spaces accessible through ethnographic research, machine learning, and 3D simulation, and an internalist or subjectivist view, which acknowledges that atmosphere is deeply tied to personal experiences, mood, culture, and context, making it difficult to quantify. The findings from this paper challenge existing frameworks, suggesting that understanding this phenomenon involves accounting for tensions between subjective experience and measurable environmental factors.

Review and concepts: In a systematic review, Valentine investigates how subtle variations in architectural forms (such as curves, proportions, and spatial enclosures) influence physiological stress responses. Supported by technological advances in wearable sensors and virtual reality (VR), the research presented in the review explores the relationship between architecture and neurological reactions. The findings suggest that specific architectural features may be correlated with stress, which could contribute to diseases such as cardiovascular and neurodegenerative disorders.

Empirical: Ecological Interaction, including studies conducted in real-world or controlled experiments.

Through a controlled experiment conducted in a home environment, Sannier et al. emphasize the importance of studying behavior in built environments under natural conditions. Focusing on indoor walking with obstacles, the study's results demonstrate continuous perceptual (visuo-motor) adaptations in walking trajectories. The article argues for the significance of incorporating real-world conditions into Human-Building

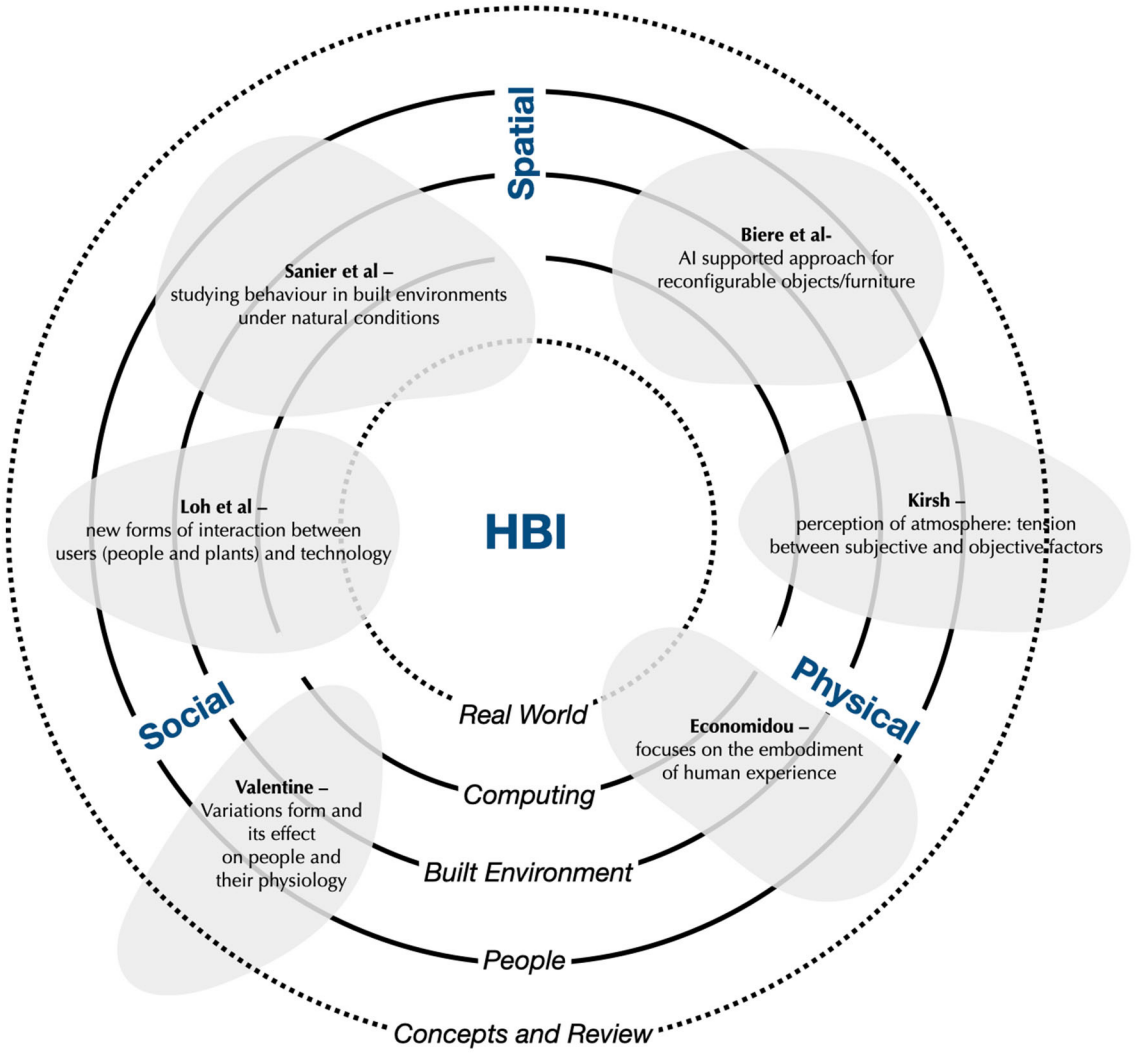

FIGURE 2
The illustration shows the scope of the articles in this Research Topic and their contribution, ranging from concepts and reviews to real-world studies. It builds on the schema proposed by Alavi et al., 2019, highlighting the three interconnected dimensions: the physical-material, spatial-configurational, and socio-cultural.

Interaction (HBI) research and provides insights into the dynamic relationship between human movement and the built environment, highlighting key metrics that can inform future HBI studies and designs.

Economidou et al. extend this approach further by advocating for the emphasis on the concept of "lived experience" in HBI studies. Through a framing discussion supported by a case study, and grounded in the central role of embodied experiences within interaction design and human-computer interaction research, the article presents arguments illustrating the necessity of introducing a new perspective in HBI—one that focuses on the embodiment of human experiences in built environments. The case study demonstrates the potential forms and frameworks that HBI design can adopt to accommodate and enhance lived, embodied experience.

Loh et al. go beyond human-centered approach and focus their study around the interaction between users (people and plants) and technology (an ambient mediator), creating a plant care system in a typical office building case study. This work presents new research designed from a non-exclusively human-centered perspective. A potted plant is no longer a decorative object but an equal occupant of the office space in its own right. Technology, indicating the amount of sunlight and water the plant has received, provides the basis for new forms of interaction, bringing both benefits and challenges, as well as creating new scenarios in the everyday lives of the participants within the space.

Applied research: technological integration, focusing on prototyping with lightweight material and experimental studies.

Bier et al. explore how an AI-driven approach can facilitate spatial reconfiguration. The study provides an interdisciplinary method for designing flexible, responsive environments. It introduces a novel pipeline D2RPA&O (Design-to-Robotic-Production-Assembly-and-Operation), an AI-supported approach

for reconfigurable furniture. This approach aims to integrate HBI with robotics and lightweight materials using 1:1 scale prototypes and focusing on material optimization, space efficiency, and comfort.

Toward a new paradigm in HBI: the rise of time-based human-building collaboration

This Research Topic aims to advance our understanding of HBI, opening the door to future cross-disciplinary collaborations, and fostering new methodologies and innovative applications. As buildings potentially gain autonomous capabilities, questions arise regarding three key factors: their impact on human physiological and emotional responses, the need to consider embodiment as a lived human experience, and the importance of incorporating real-world conditions in HBI research. The next phase of Human-Building Interaction will likely involve greater automation and real-time dynamic interactions, transforming the relationship between humans, non-humans and buildings. We envision that this shift will require a deeper understanding of how to curate and support collaboration between agents, both human and non-human. This suggests that adopting the right balance of automation is essential for advancing human-building collaboration. Future research should further consider: Human agency and experience, including embodied, collaborative, and real-time coordination, identifying key metrics to inform future HBI studies and design, and developing new standardized research methods, including the evaluation and refinement of algorithms to ensure accessibility for all relevant actors.

Author contributions

AF: Writing – original draft, Writing – review & editing. HA: Writing – review & editing. KZ-D: Writing – review & editing. AT-J: Writing – review & editing. JW: Writing – review & editing. NB-B: Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Publisher's note

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