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A Fresh Glance at Environmental Ergonomics: A Systematic Review of Human-Environment Interaction Concepts and Approaches

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ABSTRACT

The WHO's European Charter on Environment and Health emphasizes the importance of a clean and harmonious environment for good health and wellbeing, considering various factors such as physical, psychological, social, and aesthetic elements. This paper provides a comprehensive review of the role of physical space in relation to people's wellbeing and tasks, highlighting the impact of the environment on psychophysical health and human-system interactions. It focuses on the concept of environmental ergonomics, which analyzes how environmental features can support or hinder human activities and the wellbeing of its inhabitants. The paper also discusses the shift in the understanding of how spatial and environmental qualities influence wellbeing over time, emphasizing the need for clarity on intersection among several factors various factors such as satisfaction, aesthetics, ergonomics, and performance. Furthermore, it outlines a twofold approach to assessing and designing people-centered physical spaces, considering both technical variables and spatial experience. The paper provides a systematic review of key concepts to build a sort of tool kit for the environmental ergonomist, ranging from affordance and usability, to mental models and wayfinding, urban landscape, topophilia and placemaking, Post Occupancy Evaluation, multisensory, biophilia, neuroarchitecture. Finally, practical examples of environmental ergonomics application are presented, such as: healing environments, buildings for people with specific needs, environments to reduce human error, buildings to move in, emergency evacuation, smart buildings and smart cities, environments for healthy living, environments for learning and creativity.

Keywords: Human-environment interaction, Ergonomic design, Human factors techniques, Occupants

INTRODUCTION

In its European Charter on Environment and Health, the WHO (1989) states that good health and wellbeing require a clean and harmonious environment in which physical, psychological, social and aesthetic factors are all given their due importance. The space we live and act in affects psychophysical wellbeing and the way in which we execute our activities, determining specific cognitive, emotional, sensory and physical dimensions. From this foundation,

this work builds a comprehensive review of the role of physical space combining people's wellbeing and tasks. In the selection of surveyed concepts and approaches, attention has been paid to provide examples relevant for cognitive, organizational and physical interactions.

We spend almost all our lifetime in environments created by humans, all interactions are shaped in and are a consequence of the features characterising our environments. Human interaction with the environment is a sort of prefilter affecting the characteristics and quality of any other physical, cognitive and organizational human-system interactions.

This work reviews the most recent approaches to human environment interaction, looking at the environmental ergonomics as a conceptual tool to: (i) analyse environment features that can determine interaction more or less supportive our goals and the execution of the activities we carry out to accomplish such goals, (ii) assess and design the extent on which physical environment fits the needs of its inhabitants and users.

THE NEED OF RETHINKING ENVIRONMENTAL ERGONOMICS

Most common definition of environmental ergonomics consider it as a branch of ergonomics that focuses on the study of how the physical environment, including factors such as temperature control, air quality, lighting, noise, and workstation can be designed to create an environment that promotes the mental, physical, and social well-being of individuals (Thatcher, 2013). The discipline has been mainly developed in the context of occupational ergonomics, to address the influence of the environment on aspects related to the safety, efficiency, and comfort of workers. As an example, in an office workplace, environmental ergonomics typically encompasses factors such as lighting, noise, and temperature, and aims to design and set up work environments that are free of health and safety risks, comfortable, and productive (Parsons, 2000).

The discipline of ergonomics has significantly evolved, with a growing focus on various specialized areas, becoming increasingly intertwined with other scientific disciplines, such as social sciences, public health and sustainability (Crawford, 2008; Murillo-Aviña et al., 2022). As consequence, also environmental ergonomics should broaden its perspective to encompass more comprehensively (i) people centeredness, in terms of characteristics, diversity, ability/needs, inclusion, (ii) goals focus, in terms of motivations and tasks, (iii) relevance of the contexts, linked to systemic dimension and scale multiplicity, (iv) evidence based approach, namely experimental, iterative, improvement driven.

As Altomonte and colleagues evidence (2020), "how spatial and environmental qualities may influence well-being have shifted over time, emphasising the need for greater clarity on the role, meaning, contribution, and interrelations of many factors and dimensions – e.g., satisfaction, aesthetics, ergonomics, performance, flourishing, affect, etc. – in research and building practice". According to Vink et al. (2016), the relationship between the environment and human experiences delves into various aspects of the environment, including those distant from the human body, close to the body,

and touching the human body. This relation entangles different human senses and their involvement in these environmental aspects, emphasizing the need for future studies to address long-term effects and the effects of variable combinations of multiple and multi scale factors.

Assessing and designing people-centred physical spaces imply, then, a twofold approach where technical variables look at shape, proportion, layout, in/outside relation, light, noise, air quality, materials, operability, colours, maintenance, whilst spatial fruition looks at comfort, utility, density, crowd, personal space and privacy, security, belonging, inclusion/exclusion, social connections etc. In this framework, a refreshed definition of environmental ergonomics sees it as, obviously, focused on human-environment interaction and should be aimed at analysing spatial features determining the interactions that are able to favour or to hinder our goals as well as the execution of tasks, actions and operations needed to achieve those goals. This also allows the assessment and assurance of the optimal correspondence between tangible and intangible characteristics of the environment with the wide and variable range of users' psychophysical and socio-cultural characteristics, needs and purposes.

The COVID-19 pandemic has underscored the significance of space for both the physical and mental well-being of individuals. Research conducted during and after the pandemic has revealed that the design and quality of living spaces, either indoor or outdoor, can impact psychological distress and physical health conditions. Additionally, exposure to green and blue spaces has been associated with improved mental well-being and has been found to buffer the negative effects of lockdown on mental health (D'alessandro et al., 2020).

It can be said then that environmental ergonomics perfectly matches this novel awareness, and expectations towards the discipline have increased. Consequently, the same evolution should be promoted to broaden the concepts and tools constituting the discipline foundation.

BROADENING THE CONCEPTUAL AND PRACTICAL TOOLS FOR ENVIRONMENTAL ERGONOMICS

With this refreshed perspective, the following paragraphs will provide a systematic review of key concepts to build a sort of tool kit for the environmental ergonomist, attaining traditional fields such as environmental psychology, or design or service design, and less conventional references such as ecology, neurosciences, urban planning, or security. The following paragraphs present a brief overview of conceptual resources for the environmental ergonomics.

Affordance and Usability

The "affordances" of the environment are what the environment offers to the animal, what it provides or allows it to be enjoyed", for better or for worse. The verb "afford" is in the dictionary, but the noun affordance is not. Gibson (2014) made it up, with the meaning of something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment. Norman (1988)

provides some guidelines on what certain objects should and should not allow. Norman's theory culminates in two design methodologies: "design for usability" and "design for error", incorporating affordance as fundamental to the design of any artifact. Regarding architectural theory, affordances can be used as a conceptual framework to understand the relationship between environment and occupants, particularly with respect to shape and function. Regarding architectural practice, affordances can be used as a tool to explore the connection between project intentions with how buildings and spaces are actually used to avoid design errors (Maier et al., 2009).

Usability is one of the most important, but most often overlooked, aspects of building performance. Performance is related to usability at a given time. Therefore, usability is a concept related to time, place, context and situation. A better exploitation of the concept in the field of built environment will be useful not only in the evaluation of buildings already in use, but also for a better understanding of what the relevant knowledge could be to include in the design briefing process (Alexander, 2006).

Mental Models and Wayfinding

The mental model is the representation of a system or environment derived from experience, which allows predictions and inferences (Craik, 1952). It is a mechanism we use to predict what will happen when we interact with a system (Norman, 1983). In the built environment, the construction of a correct mental model helps the user to achieve their goals and use the building in accordance with the intended ways (Duca, 2014). Wayfinding is a coherent use and organization of sensory signals defined by the external environment (Lynch, 1960). Wayfinding is the finding of the way to a destination through spatial problem solving, comprising three interdependent processes: decision making, decision execution, and information processing (Arthur and Passini, 1992). It involves 4 phases: Orientation, Route decision, Route monitoring and Destination recognition (Downs and Stea, 2005). Wayfinding addresses components such as spatial planning, circulation systems, and environmental communication to provide a clear understanding of the environmental space and city's routes (Cheirchanteri, 2021). The key design element of wayfinding can be summed up in: identity, landmarks & breadcrumbs, paths, differing regions, limiting navigational choices, signs at decision points, sight lines (Apelt et al., 2007).

Urban Landscape, Topophilia, Placemaking

The pleasantness of the urban environment is fundamental for aggregation, social exchange, meeting; the human being's ability to enjoy or hate urban space is triggered by the structure of buildings, the landscape and the shapes of the city (Cullen, 1961). Its key elements are: (i) optics: visual ability of humans to enjoy cinematic view, movement, beautiful sequences; humans can feel them as they move through city spaces and view the changing scenery; (ii) place: the quality of urban spaces that gives the feeling of inside/outside, inclusion/exclusion; (iii) content: it is related to the detail of urban spaces such as color, texture, style, scale and uniqueness. Topophilia is an emotional

bond between people and place, which influences the vision of the world and determines perceptions, attitudes and values. It is characterized by three dimensions (Tuan, 1974). The functional dimension represents the role of physical space as an attractor, encourager or inhibitor of movements, which interfere with the behaviors that occur there, which can generate both well-being and frustration and stress. The symbolic dimension has a socio-cultural and individual content, it influences the way in which everyone acts on different situations. The relational dimension concerns the sense of cognitive and emotional connection between people and the characteristics of the environment, in which the individual is perceived as belonging to the group and to a specific place, identifying a unique relationship between them. The thinking behind placemaking dates back to the 1960s, when US activists floated revolutionary ideas about designing cities for people, not just cars and shopping malls. Their work focuses on the social and cultural importance of vibrant neighborhoods and inviting public spaces (Jacobs, 1961). Since the 1990s, placemaking is a multifaceted approach to the planning, design and management of public spaces (Bennett, 2014). It aims at harnessing the resources, inspiration and potential of a local community, with the intention of creating public spaces that promote people's health, happiness and well-being. Placemaking transcends the material dimension and involves aspects such as sociability, uses, activities, access, connections, comfort and image, to create bonds between people and a sense of place. Finally it maintains a connotation of social activism (tactical urbanism), because it also acts with bottom-up initiatives to change the nature of the identity of places to make them more inclusive.

Post Occupancy Evaluation

Post Occupancy Evaluation (POE) was born following the conceptualization of the concept of Sick Building Syndrome (Stolwijk, 1991). It is the process of systematically and rigorously evaluating buildings after they have been constructed and occupied for a certain time; POE consists in diagnostic tools and systems that allow facility managers to systematically identify and evaluate critical aspects of building performance (Preiser, 1995). Generally, it concerns the physical-technical component and management and it is also used to monitor the impact of spending on public buildings. It is central to bridging the gap between designed intentions and actual results in use, and generates recommendations based on the experiences of all stakeholder groups on the effects of buildings. Other elements and aspects emerge from user involvement that impact productivity and, in its most recent meanings, POE is not just about energy efficiency and user satisfaction but investigates the extent on which a building meets the needs of the building's clients and occupants, including more intangible issues such as productivity, identity, atmosphere and community (Leaman and Bordas, 2001; Behar et al., 2017)

Multisensory Approach and Biophilia

Human experiences within built environments affect human well-being (Noguchi et al., 2022); the built environment triggers human perceptions,

each space creates opportunities for everyday sensory experiences. Traditionally, architectural practice has been dominated by the sense of sight, but there is a growing recognition of the importance of other senses such as sound, touch, smell, and even taste in design (Spence, 2020). Every single element that configures the environment determines perceptions on which physical, biological and psychological reactions depend. Sight, sound, touch (including proprioception, kinesthesia and vestibular sense), smell (on rare occasions, even taste) affect fatigue, circadian rhythms, comfort, stress, sense of security, attention, memory, pleasure. Nature as specific "technical" component of design that is able to provide emotional support to the built environment's users is the core of the concept of "biophilia". Edward O. Wilson (1993) postulated a human need to connect with living structure in our environment; also Richardson and colleagues (2016) explore the relationship between nature, well-being, and ergonomics, arguing that incorporating nature into the design of work environments can positively impact the well-being and productivity of individuals. There is evidence that natural elements (i.e. water, natural materials, plants, natural landscapes, access to open spaces, views of nature) induce positive psycho-physical conditions (Aenne et al., 2022) and enhance cognitive function, attention span, and problem-solving abilities (Stouhi, 2020). Incorporating nature in user centred building design allows to create built environment relevant for human cognitive and emotional development, both individually and collectively, (Noguchi et al., 2022; Spence, 2020) and human performances, guiding users towards thriving in their activities. De Paiva and Jedon (2019) emphasize that spaces continue to influence individuals in both the short and long term proposing a theoretical formalization of this relationship, and providing insights into how architectural design can affect the brain and human behavior in various ways.

Neuroarchitecture

The possibility of recording the neural activity of subjects during exposure to environmental situations, using neuroscience and virtual reality is arising growing interest, with the resulting discipline is called "neuroarchitecture". Neuroarchitecture is a field that explores the neurophysiological foundations of the cognitive-emotional dimension of architecture and the neuro-behavioral effects generated by architectural design. It aims to understand how the built environment influences the human brain and human sensory experiences in built environments (Higuera-Trujillo et al., 2021). De Paiva and Jedon (2019) demonstrate how the built environment can directly influence the unconscious and conscious mind, playng a crucial role in determining psychological outcomes, even during aging and neurodegenerative conditions. Despite its potential, the field of neuroarchitecture is still evolving, and there are challenges and limitations that need to be addressed to further its development and application (Higuera-Trujillo et al., 2021; Wang et al., 2022), especially the need for more empirical research on the embodied implications of neuroarchitecture for the built environment (Lee et al., 2022).

PRACTICAL APPLICATIONS OF ENVIRONMENTAL ERGONOMICS EMERGING CONCEPTS

Environmental ergonomics has diverse practical applications, ranging from promoting health and well-being in healing environments to designing inclusive spaces for specific needs and reducing human error in safety-critical buildings. It also plays a role in creating healthy urban environments and fostering creativity and learning in educational spaces.

In one of the earliest studies on healing environment, Ulrich (1984) investigated the impact of a natural view on postoperative recovery. The research found that surgical patients assigned to rooms with windows facing a natural scene had shorter postoperative hospital stays, received fewer negative evaluative comments in nurses' notes, and took fewer potent analgesics compared to patients in similar rooms with windows facing a brick wall. Research has shown that elements such as natural views, spatial comfort, safety, autonomy, and privacy can significantly influence patient recovery and well-being as well as healthcare personnel performances (Schreuder et al., 2016; Van den Berg, 2005; Huisman et al., 2012).

Designing buildings for the autonomy of people with specific needs is an important aspect of creating inclusive spaces. Spatial and technical characteristics of built environment can act as obstacle or facilitator for individual's abilities and characteristics. Designing buildings to match specific needs, such as those of individuals with dementia, the elderly, or autism spectrum disorder, involves considering spatial and technical characteristics to foster greater autonomy and improve quality of life (Marquardt, 2011; Noguchi et al., 2018; Terzi, 2010 (Tola et al., 2021). Under a different perspective, factors such as lighting, openness, visibility, permeability of building frontages, natural surveillance and the presence of others can enhance women's safety perceptions while walking in public spaces. (Scarponi et al., 2023; Sadeghiet al., 2023). In safety-critical buildings, architectural design and technology play a vital role in ensuring optimal human performance in accomplishing working tasks. For instance, in the case of control centres, control room layouts, furniture, lighting, and temperature, can also help minimize operator fatigue and error, thus reducing human error in process safety (Attaianese and Duca, 2012). The relevance of such approach is also acknowledged in relation to safety-critical elements in building construction. Safety-critical elements are those that, if they fail, are omitted, or incorrectly installed, carry an unacceptable risk of causing serious injury or fatality (Pitchers, 2023). In this context, the consideration of human abilities and behavior as well as and the needs of different occupant groups during emergencies is a crucial part of building safety and emergency preparedness, as it affects the effectiveness of evacuation strategies (Olander et al., 2016; Künzeret al., 2020) and inclusive safety. There are evidences of the associations between urban form and various health outcomes, such as weight status, blood pressure, and injuries, whilst there are studies investigating unavoidable negative impacts of urban form on health (WHO, 2019; McCormack et al., 2019). Also under the mental health perspective, there is consensus on people with access to high-quality spaces experiencing better mental health than people with

access to only spaces of low quality (Francis et al., 2012; D'Appolloni et al., 2020; McCormack et al., 2019; Francis et al., 2012; Cameron et al., 2012). Designing buildings to support human interaction can facilitate creativity, collaboration, and innovation. Environmental ergonomics can inform the design of factors such as layout, use of space, lighting, and color choices to achieve this goal (Soares et al., 2022; Gifford, 2002; Graetz, 2006) and to shaping the emotional and behavioral engagement of students and teachers in learning environments (Cheryan et al., 2014).

CONCLUSION

Environment plays a key role in supporting individuals' goals and the execution of their activities, ultimately influencing their effectiveness. The paper has discussed the need to broaden the conceptual and practical tools for environmental ergonomics, emphasizing the importance of incorporating knowledge and techniques related to series of concepts that are usually addressed separately. Also, an attempt has been made to demonstrate that the knowledge embedded in all the mentioned concepts and approaches should be applied in its whole, independently on the specific field and purposes in which they have been developed. A fresh glance at environmental ergonomics is crucial for its incorporation in building and urban design practices, due to its impact on the design and quality of the physical environment and its influence on individuals' mental, physical, and social health.

REFERENCES

Alexander, K. (2006). The application of usability concepts in the built environment. Journal of Facilities Management.

Altomonte, S., Allen, J., Bluyssen, P. M., Brager, G., Heschong, L., Loder, A.,... & Wargocki, P. (2020). Ten questions concerning well-being in the built environment. Building and Environment, 180, 106949.

Apelt, R., Crawford, J., & Hogan, D. J. (2007). Wayfinding design guidelines. CRC for Construction Innovation.

Appolloni, L., Giretti, A., Corazza, M. V., & D'Alessandro, D. (2020). Walkable Urban Environments: An Ergonomic Approach of Evaluation. Sustainability, 12(20), 8347.

Arthur, P. and Passini, R. (1992). Wayfinding: People, Signs, & Architecture. McGraw-Hill, New York.

Attaianese, E., & Duca, G. (2012). Human factors and ergonomic principles in building design for life and work activities: An applied methodology. Theoretical Issues in Ergonomics Science, 13(2), 187–202.

Behar, C., Bradshaw, F., Bowles, L., Croxford, B., Chen, D., Davies, J.,... & Von Bradsky, A. (2017). Building Knowledge: Pathways to Post Occupancy Evaluation. Reading: RIBA (Royal Institute of British Architects) and University of Reading.

Bennett, Jamie (2014). "Creative Placemaking". Community Development INVESTMENT REVIEW. 10 (2, 2014): 77–82.

Brielmann, A. A., Buras, N. H., Salingaros, N. A., & Taylor, R. P. (2022). What happens in your brain when you walk down the street? implications of architectural proportions, biophilia, and fractal geometry for urban science. Urban Science, 6(1), 3.

Cameron, C. M., Scuffham, P. A., Spinks, A., Scott, R., Sipe, N., Ng, S., Wilson, A., Searle, J., Lyons, R. A., Kendall, E., Halford, K., Griffiths, L. R., Homel, R., & McClure, R. J. (2012). Environments for Healthy Living (EFHL) Griffith birth cohort study: Background and methods. Maternal and child health journal, 16(9), 1896–1905. https://doi.org/10.1007/s10995-011-0940-4

Cheirchanteri, G. (2021, November). Architectural Wayfinding Design as a Means of Communication in Environmental Perception. In IOP Conference Series: Materials Science and Engineering (Vol. 1203, No. 3, p. 032003). IOP Publishing.

Cheryan, S., Ziegler, S. A., Plaut, V. C., & Meltzoff, A. N. (2014). Designing classrooms to maximize student achievement. Policy Insights from the Behavioral and Brain Sciences, 1(1), 4–12.

Craik, K. J. W. (1952). The nature of explanation. CUP Archive.

Crawford, J. (2005). The development of ergonomics as a scientific discipline. Occupational Hygiene, 373–388.

Cullen, G. (1961). Townscape, The Architectural press, London.

D'alessandro, D., Gola, M., Appolloni, L., Dettori, M., Fara, G. M., Rebecchi, A.,... & Capolongo, S. (2020). COVID-19 and living space challenge. Well-being and public health recommendations for a healthy, safe, and sustainable housing. Acta Bio Medica: Atenei Parmensis, 91(9-S), 61.

De Paiva, A., & Jedon, R. (2019). Short-and long-term effects of architecture on the brain: Toward theoretical formalization. Frontiers of architectural research, 8(4), 564–571.

Downs, R. M., & Stea, D. (Eds.). (1973). Image and environment: Cognitive mapping and spatial behavior. Transaction Publishers.

Francis, J., Wood, L. J., Knuiman, M., & Giles-Corti, B. (2012). Quality or quantity? Exploring the relationship between Public Open Space attributes and mental health in Perth, Western Australia. Social science & medicine, 74(10), 1570–1577.

Gabriella Duca (2014) From energy-efficient buildings to energy-efficient users and back: ergonomic issues in intelligent buildings design, Intelligent Buildings International, 6:4, 215–223.

Gibson, J. J. (2014). The ecological approach to visual perception: Classic edition. Psychology press.

Gifford, R. (2002). Environmental Psychology: Principles and Practices (2nd ed.). Boston, MA: Pearson Custom Publishing.

Graetz, K. A. (2006). The psychology of learning environments. Educause Review, 41(6), 60–75.

Higuera-Trujillo, J. L., Llinares, C., & Macagno, E. (2021). The cognitive-emotional design and study of architectural space: A scoping review of neuroarchitecture and its precursor approaches. Sensors, 21(6), 2193.

Huisman, E. R., Morales, E., van Hoof, J., & Kort, H. S. (2012). Healing environment: A review of the impact of physical environmental factors on users. Building and environment, 58, 70–80.

Jacobs, Jane (1961). The death and life of great American cities. New York: Random House.

Kellert, S. R., & Wilson, E. O. (Eds.). (1993). The biophilia hypothesis. Island press.

Künzer, L., Hofinger, G., & Zinke, R. (2020). Safe Evacuation for All A top 10 List of Requirements. Collective Dynamics, 5, 197–204.

Leaman, A., & Bordass, B. (2001). Assessing building performance in use 4: The Probe occupant surveys and their implications. Building Research & Information, 29(2), 129–143.

Lee, S., Shin, W., & Park, E. J. (2022). Implications of neuroarchitecture for the experience of the built environment: A scoping review. Archnet-IJAR: International Journal of Architectural Research, 16(2), 225–244.

Lynch, K. 1960. The Image of the City. Cambridge: MIT-Press.

Maier, J. R., Fadel, G. M., & Battisto, D. G. (2009). An affordance-based approach to architectural theory, design, and practice. Design Studies, 30(4), 393–414.

Marquardt, G. (2011). Wayfinding for people with dementia: A review of the role of architectural design. HERD: Health Environments Research & Design Journal, 4(2), 75–90.

McCormack, G. R., Cabaj, J., Orpana, H., Lukic, R., Blackstaffe, A., Goopy, S.,... & Fabreau, G. (2019). Evidence synthesis A scoping review on the relations between urban form and health: A focus on Canadian quantitative evidence. Health promotion and chronic disease prevention in Canada: research, policy and practice, 39(5), 187.

Murillo-Aviña, G. J., Mellink-Méndez, S. K., López-Leyva, J. A., & Ramos-García, V. M. (2022). Challenges and Opportunities Post Pandemic of Organizational Ergonomics to Promote the Social Sustainability in Cultural and Creative Industries: A Critical Review and Future Research Agenda. Sustainability, 14(22), 15120.

Noguchi, M., Lan, L., Chowdhury, S., & Yang, W. (2022). Environmental experience design research spectrum for energy and human well-being. In Handbook of Energy and Environmental Security (pp. 207–229). Academic Press.

Noguchi, M., Ma, N., Woo, C. M. M., Chau, H. W., & Zhou, J. (2018). The usability study of a proposed environmental experience design framework for active ageing. Buildings, 8(12), 167.

Norman, D. A. (1988). The psychology of everyday things. Basic books.

Norman, D. A. (1983). Some observations on mental models. Human-Computer Interaction, 241–244.

Olander J., Ronchi E., Lovreglio R., Nilsson, D. (2016) Dissuasive exit signage for building fire evacuation. Applied Ergonomics.

Parsons, K. C. (2000). Environmental ergonomics: A review of principles, methods and models. Applied ergonomics, 31(6), 581–594.

Pitchers, S. (2023). Safety-Critical Elements in Building Construction CIOB-RIBA

Preiser, W. F. (1995). Post-occupancy evaluation: How to make buildings work better. facilities, 13(11), 19–28.

Richardson, M., Maspero, M., Golightly, D., Sheffield, D., Staples, V., & Lumber, R. (2016). Nature: A new paradigm for well-being and ergonomics. Ergonomics, 1–14.

Sadeghi, A. R., Baghi, E. S. M. S., Shams, F., & Jangjoo, S. (2023). Women in a safe and healthy urban environment: Environmental top priorities for the women's presence in urban public spaces. BMC women's health, 23(1), 1–21.

Scarponi, L., Abdelfattah, L., Gorrini, A., Valenzuela Cortés, C., Carpentieri, G., Guida, C.,... & Choubassi, R. (2023). Thematic Review on Women's Perception of Safety While Walking in Public Space: The STEP UP Project. Sustainability, 15(21), 15636.

Schreuder, E., Lebesque, L., & Bottenheft, C. (2016). Healing environments: What design factors really matter according to patients? An exploratory analysis. HERD: Health Environments Research & Design Journal, 10(1), 87–105.

Soares, I., Venhorst, V., Weitkamp, G., & Yamu, C. (2022). The impact of the built environment on creativity in public spaces of Dutch university campuses and science parks. Journal of Urban Design, 27(1), 91–109.

Spence, C. (2020). Senses of place: architectural design for the multisensory mind. Cognitive Research: Principles and Implications, 5(1), 1–26.
Stolwijk, J A (1991). "Sick-building syndrome". Environmental Health Perspectives. 95: 99–100.
Stouhi, D. (2020). "Bringing the Outdoors Inside: The Benefits of Biophilia in Architecture and Interior Spaces" 12 Nov 2020. ArchDaily. Accessed 11 Feb 2024. <https://www.archdaily.com/923100/bringing-the-outdoors-inside-the-benefits-of-biophilia-in-architecture-and-interior-spaces> ISSN 0719–8884
Terzi, L. (2010). What metric of justice for disabled people? Capability and disability. Measuring justice: Primary goods and capabilities, 150–173.
Thatcher, A. (2013). Green ergonomics: definition and scope. Ergonomics, 56(3), 389–398.
Tola, G., Talu, V., Congiu, T., Bain, P., & Lindert, J. (2021). Built environment design and people with autism spectrum disorder (ASD): A scoping review. International journal of environmental research and public health, 18(6), 3203.
Tuan, Y. F. (1990). Topophilia: A study of environmental perception, attitudes, and values. Columbia University Press.
Ulrich, R. S. (1984). View through a window may influence recovery from surgery. science, 224(4647), 420–421.
Van den Berg, A. E. (2005). Health impacts of healing environments; a review of evidence for benefits of nature, daylight, fresh air, and quiet in healthcare settings. UMCG.
Vink, P., Bazley, C., & Jacobs, K. (2016). Modeling the relationship between the environment and human experiences. Work, 54(4), 765–771.
Wang, S., Sanches de Oliveira, G., Djebbara, Z., & Gramann, K. (2022). The embodiment of architectural experience: A methodological perspective on neuro-architecture. Frontiers in human neuroscience, 16, 236.
World Health Organization. (1989). European charter on environment and health. WHO Regional Office for Europe, Copenhagen, 430.
World Health Organization. (2019). Global action plan on physical activity 2018–2030: More active people for a healthier world. World Health Organization.