

Fostering Emotions Elicited in Livable Spaces: Using Virtual Reality to Study Ergonomics and Architecture Determinants in Home Office Spaces

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Keywords

Ergonomics, Built Environment, Emotional Design,
Virtual Reality, Home Office

Partner Institutions

University of Beira Interior - Portugal

Expected Future Partner Institutions

Federal University of Pernambuco – Center of Arts and
Communication- Brazil

OBJECTIVES

This project seeks to contribute to the growing body of knowledge related to Ergonomic on built environment by investigating the emotional responses elicited by determinants of the spaces, namely home offices spaces, specifically focusing on three determinants: biophilia, privacy, and cluttered space. Virtual Reality (VR) will be used as interaction environment. Biosensors that measures bio signals, such as Electrodermal activity and heart rate will be used as objective measures to be correlated with more subjective responses collected through interviews and validated tools.

The specific objectives are:

- To assess the emotional impact of biophilic elements within a home office space.
- To evaluate the influence of privacy levels on individuals' emotional states in a home office setting.
- To examine how cluttered spaces affect individuals' emotions and productivity in a home office environment.
- To compare and analyze the emotional responses evoked by various combinations of biophilia, privacy, and cluttered space in home office design.
- To explore the potential correlations between emotional responses and participants' subjective evaluations of the home office options.
- To investigate cross-cultural differences between Portugal and Brazil

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ABSTRACT + IMAGES

The design of our built environment has a significant impact on our emotions and overall well-being (Reddy et al., 2012). Numerous studies (e.g., see Bringslimark et al., 2009 for a critical review about the psychological benefits of indoor plants, Tantanawin & Inkarojit, 2017) have investigated the effect of indoor space elements on human emotions, shedding light on the intricate relationship between our surroundings and our emotional experiences. The COVID-19 pandemic has led to a substantial increase in remote work (Appel-Meulenbroek et al., 2022), making home-offices a critical area for ergonomics on built environment. The emotional impact of home-office spaces on individuals has become even more significant, as they often serve as multifunctional environments where work and personal life converge.

The field of ergonomics in the built environment emphasizes the importance of creating spaces that are not only physically comfortable but also supportive of emotional experiences (Reddy et al., 2012). Thus, understanding the relationship between space elements, ergonomics, and emotional experiences in home office settings is essential for creating supportive and healthy work environments.

In this context, this project seeks to contribute to this growing body of knowledge by exploring the emotional impact of space elements in the context of home office environments. So, considering the field of Ergonomics and Human Factors on built environment, this study aims to investigate the emotional responses elicited by physical elements of the home-offices spaces, specifically focusing on three determinants: greenery, privacy, and cluttered space. See an example on Fig.1. Virtual Reality (VR) will be used as interaction environment in which these three elements will be tested with people using different home-office spaces specifically designed for the study purpose. By using Virtual Reality (VR) as a tool to present different home office spaces, we can create immersive and realistic environments as the same time we are able to enhance the control of other environment features which are not the focus of the study, allowing us to increase the study's ecological validity. Biosensors that measure bio signals, such as electrodermal activity (EDA) and heart rate (HR) - see Fig. 2 - will be used as objective measures to be correlated with more subjective responses collected through interviews and validated tools (for example, SAM and Geneva Emotion Wheel, (Fig.3).

By exploring the effects of greenery, privacy, and cluttered space on emotions, this research aims to provide valuable insights for designing emotionally supportive and productive home office spaces.

Biophilia, the innate human affinity for nature, has been extensively studied in relation to the built environment and its effect on emotions. Researches (e.g., Kellert et al., 2008 and Ryan & Browning, 2020) has shown that incorporating biophilic design elements, such as greenery, natural lighting, and natural materials, may evoke positive emotions, enhance well-being, satisfaction, and productivity. These elements have been found to reduce stress levels, promote relaxation, and foster a sense of connection with the natural environment.

Privacy, another crucial aspect of architectural design, plays a vital role in shaping emotional experiences. Studies (e.g., Kaplan & Kaplan, 1989; Wütschert et al., 2022) have demonstrated that increased privacy within a workspace positively influences emotional well-being by reducing stress and distractions. Privacy provides individuals with a sense of personal control, allowing them to focus on their tasks and achieve a state of flow, leading to improved work performance and emotional satisfaction.

The presence of clutter in our surroundings can also significantly impact our emotions and productivity. Saxe and Repetti (2010) have explored the effects of cluttered spaces on emotional well-being and have found that clutter can evoke negative emotions and increase stress levels. Cluttered environments are often associated with feelings of overwhelm, decreased concentration, and reduced productivity. On the other hand, organized and decluttered workspaces have been linked to improved focus, clarity of mind, and a sense of calmness.



Fig. 1 Examples of Home office with low privacy with (left) and without (right) biophilia.



Fig. 2 Biosensors used together with HTC VIVE controllers.

It is essential to understand the interplay between these spaces' determinants. Some authors (e.g., Tennessen & Cimprich, 1995) have highlighted the synergistic effects of biophilia, privacy, and cluttered space on emotional responses. Different combinations of these determinants can evoke distinct emotional experiences. For example, a workspace with abundant natural light, high privacy, and minimal clutter may promote feelings of tranquility and enhanced concentration.

Furthermore, subjective evaluations of architectural qualities align with emotional experiences. Studies have shown that individuals' perceptions of their environments are closely linked to their emotional responses. Participants' subjective evaluations of home office options can serve as a valuable indicator of emotional experiences, providing insights into the impact of space determinants on overall satisfaction and preference.

This project proposal introduces several novel aspects that contribute to the existing body of knowledge regarding the impact of architectural elements on human emotions, particularly in the context of home office spaces. These aspects include:

-Focus on Home Office Spaces: The project specifically examines the influence of space determinants on human emotions within home office environments. This focus recognizes the increasing prevalence of remote work and the need to understand the emotional dynamics of these spaces. The project provides tailored insights and recommendations for individuals working from home.

- Integration of VR Technology: The use of virtual reality (VR) technology enhances the research on ergonomics in the built environment. By immersing participants in virtual environments, the project enables a realistic experience to better understand how architectural design elements elicit emotional responses. This utilization of VR technology enhances the ecological validity of the study.

- Investigating the Interplay between Determinants: The project explores the combined effects of multiple space determinants, including biophilia, privacy, and cluttered space. While previous studies have examined these factors individually, their combined impact within home office spaces is relatively unexplored. By investigating the synergistic effects of these determinants, the project provides a comprehensive understanding of their influence on emotions and offers insights for optimal design integration.

- Correlation with Subjective Evaluations: The project emphasizes the correlation between emotional responses and participants' subjective evaluations of home office options. By capturing perceptions and preferences, the research adds a subjective dimension to the study of emotional experiences. This correlation contributes to a more comprehensive understanding of the emotional impact of architecture on overall satisfaction and preference. It informs the development of design guidelines and strategies for creating emotionally supportive home office environments.

The integration of a cross-cultural investigation between Brazil and Portugal in this research project offers the opportunity to examine the impact of architecture determinants on human emotions in home office spaces within different cultural contexts. This approach brings several advantages, including the exploration of cultural variations in how architecture influences emotions, enhanced generalizability of findings, and the identification of design principles transferable across cultures. By considering the cultural nuances and comparing the results from both countries, the research project can provide valuable insights into the relationship between architecture and emotions, informing the development of culturally responsive design guidelines for home office spaces.

Combining these aspects, the project proposal provides specific insights and recommendations for the design of emotionally supportive home office spaces, thereby enhancing well-being and productivity. The results of this study can inform companies that promote remote work, emphasizing the importance of considering the home office environment as an extension of the company workspace. The integration of VR technology with biosensors, the investigation of the interplay between determinants, and the correlation with subjective evaluations expand our understanding of how the built environment impacts human emotions, particularly in the context of home office spaces.

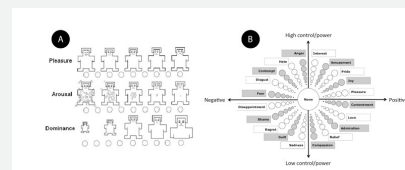


Fig. 3 SAM (A) and Geneva Emotion Wheel (B) instruments.

SCIENTIFIC RELEVANCE FOR THE DISCIPLINE

Ergonomics provides a holistic understanding of the interaction between humans and their environment, considering physical, cognitive, and emotional factors. By incorporating ergonomic considerations in the scope of built environment, we can gain insights into the complex interplay between architecture determinants, ergonomic design, and emotional experiences within home office spaces. This holistic perspective enriches our understanding of the emotional impact of design decisions and enhances the overall knowledge in the field. Focusing on ergonomics on built environment, we can deepen our understanding of how the physical design of home office spaces, in conjunction with ergonomic principles, influences emotional experiences and overall well-being. Additionally, adopting a setup based on VR as interaction environment and biosensors to collect objective data to be related with Human emotions allow us to decrease the subjectiveness generally associated to studies on environmental perception and architecture, also contributing to the development of more controlled methodological protocols that can be easier to apply than visiting real places.

EXPECTED ECONOMIC AND SOCIAL IMPACT

By investigating the impact of architecture determinants on human emotions and considering ergonomics in home office spaces, the project can contribute to the development of more efficient and productive work environments. Improved ergonomic design and can enhance comfort, well-being, and productivity, leading to increased job satisfaction and potentially higher work performance. This, in turn, can positively impact economic outcomes for individuals, organizations, and the overall economy. The project's findings can have also significant social implications. As remote work becomes increasingly prevalent, the design of home office spaces plays a crucial role in individuals' overall well-being and work-life balance. By focusing on the impact of space determinants on emotions, the project can contribute to the creation of more supportive and conducive home office environments. This can result in improved mental health, reduced stress levels, and enhanced overall quality of life for individuals working from home. Moreover, by considering the social aspects of ergonomics on built environment, the project can promote inclusivity, accessibility, and Human-centred design in home office spaces, benefiting individuals from diverse backgrounds. Overall, the economic impact of the project lies in the potential for increased productivity and job satisfaction, while the social impact lies in improved well-being and work-life balance for individuals working in home office spaces. These outcomes can contribute to a more efficient and sustainable workforce, fostering positive economic and social development at both the individual and societal levels.

RESEARCH PLAN AND TASKS

This project seeks to investigate the emotional responses elicited by determinants of the spaces, namely home office spaces, specifically focusing on three determinants: biophilia, privacy, and cluttered space. Considering this, the following specific objectives were defined:

- To assess the emotional impact of biophilic elements within a home office space.
- To evaluate the influence of privacy levels on individuals' emotional states in a home office setting.
- To examine how cluttered spaces affect individuals' emotions in a home office environment.
- To compare and analyze the emotional responses evoked by various combinations of biophilia, privacy, and cluttered space in home office design.
- To explore the potential correlations between emotional responses and participants' subjective evaluations of the home office options.

Based on a literature review, the following hypotheses were formulated:

- Home office spaces that incorporate biophilic design elements will elicit positive emotions, contributing to enhanced well-being, satisfaction, and productivity;
- Increased privacy within a home office will positively influence emotional well-being by reducing stress and distractions, thereby fostering a conducive work environment
- Cluttered home office spaces will evoke negative emotions, leading to decreased focus and reduced productivity, highlighting the importance of an organized and decluttered workspace;
- Different combinations of biophilia, privacy, and cluttered space will generate distinct emotional responses, emphasizing the need to understand the synergistic effects of these determinants on emotions in home office design;
- Participants' subjective evaluations of home office options will align with their emotional responses, indicating a correlation between emotional experiences and perceived architectural qualities.

To test the hypothesis and achieve the defined objectives, a within-subject design will be considered in which stimulus will be presented to participants in an immersive virtual environment using a VR-based methodology. The independent variables are related to the three architecture determinants (i.e., Biophilia, privacy and cluttered). Considering that each one of them has two levels and that they can be combined, a total of 20 stimuli will be considered. Dependent variables are divided into two classes, subjective measures (i.e., emotional response collected through Self-Report Measures and Subjective evaluations) and Objective measures (i.e., EDA and Heart rate).

Thus, a research plan comprising six main tasks will be followed:

Task 1 – Literature Review and Hypothesis Formulation

- Deep in the literature review.

- Identify relevant studies and authors supporting hypotheses and findings.

Task 2: Virtual Environment Design and Development

- Design and create high-quality 3D models of home office spaces that represent different combinations of biophilia, privacy, and clutteredness.
- Implement 3D models on a graphic engine (e.g., Unity and Unreal).
- Define and implement interactive features and navigation methods to facilitate participants' exploration of virtual environments.
- Ensure realistic rendering of lighting, materials, furniture, and other architectural elements to enhance the participants' sense of presence in the virtual environments.
- Test and refine the virtual environment design based on user feedback and technical considerations.

Task 3: Experimental Setup

- Define the target population and criteria for participant selection.
- Develop strategies for participant recruitment, such as online advertisements or collaboration with relevant organizations.
- Screen potential participants based on the defined criteria and obtain their informed consent.
- Set up the experimental procedure, including randomization of home office configurations and the order of participant sessions.
- Define the Application Protocol for the data collection phase considering the instructions that should be given to the participants, methods to be used for data collection, placement of sensors on participants, VR-training phase and the experiment.
- Test and refine the application protocol based on user feedback and the study's objectives.

Task 4: Data Collection

Conduct VR sessions with participants, administering the Application Protocol to collect data on emotional responses and subjective evaluations. The same protocol will be applied in Portugal and Brazil.

- Self-Report Measures:** Administer standardized self-report measures to capture participants' emotional responses and subjective evaluations of the home office configurations. Participants will rate their emotional experiences using scales such as the Positive and Negative Affect Schedule (PANAS) or the Self-Assessment Manikin (SAM). Subjective evaluations will be obtained using Likert scales or questionnaires assessing well-being, satisfaction, productivity, and architectural qualities.
- Biosensor Data:** Collect physiological data using biosensors, such as Electrodermal Activity (EDA) and Heart Rate monitors. Participants will wear the biosensors during the VR sessions to capture real-time physiological responses related to emotional arousal and stress levels.

Task 5: Data Analysis

a. **Self-Report Measures:** Analyze the self-report data using statistical techniques such as descriptive analysis, t-tests, ANOVA, or regression analysis. Examine the relationship between the architecture determinants and participants' emotional responses and subjective evaluations. Validate the hypotheses by determining whether the biophilic design elements, privacy levels, and clutteredness significantly influence well-being, satisfaction, and productivity.

b. **Biosensor Data:** Preprocess and analyze the biosensor data, such as EDA and Heart Rate, using appropriate signal processing techniques. Identify physiological patterns associated with different home office configurations and emotional experiences. Correlate the biosensor data with self-report measures to explore the relationship between physiological responses and participants' emotional and subjective responses.

By collecting both self-report measures and biosensor data, the research can gain a comprehensive understanding of the participants' emotional experiences and physiological responses concerning the architecture determinants. The analysis of the data will involve statistical techniques to examine the relationships, validate the hypotheses, and determine the impact of biophilic design elements, privacy levels, and clutteredness on well-being, satisfaction, productivity, and emotional states.

Task 6: Project Management and Dissemination

- Implement a project management plan to ensure efficient coordination, monitoring, and communication throughout the research project.
- Regularly review and assess the progress of the project, addressing any potential issues or challenges.
- Prepare a comprehensive research report documenting the research objectives, methodology, findings, and implications.
- Review and refine the research report, ensuring clarity and coherence.
- Present the research findings at conferences or seminars and publish the results in peer-reviewed journals to contribute to the existing body of knowledge.
- Explore opportunities for public engagement and dissemination of research findings through media, press releases, or online platforms.

By reorganizing the research plan into these six tasks, it provides a more comprehensive overview of the project's key components, including virtual environment design and development. Additionally, the inclusion of project management and communication tasks ensures efficient project coordination and effective dissemination of research outcomes.

EXPECTED SCIENTIFIC RESULTS

Overall, the expected scientific results of the proposed research project aim to contribute to the existing body of knowledge, advance understanding in the field of ergonomics on the built environment and provide practical insights for designing home office spaces that positively impact human emotions and well-being. Focusing on the investigation of the specific space determinants that have the most significant impact on human emotions and their interaction and synergistic effects can help in developing guidelines and recommendations for designing home office spaces that promote positive emotional experiences and can contribute to a deeper understanding of how they collectively influence emotional responses. This understanding can inform future design practices and enhance the overall effectiveness of home office spaces. Additionally, the study aims to explore the correlation between objective measures (such as biosensor data) and subjective evaluations (such as self-report measures). The scientific results can provide insights into the relationship between physiological responses and emotional experiences, validating the subjective perceptions of participants and strengthening the overall findings. Thus, the research project can contribute to the field of ergonomics in built environments by providing empirical evidence and insights into the relationship between space determinants, human emotions, and well-being in home office spaces. The results can inform the development of evidence-based design principles and guidelines for creating ergonomically optimized and emotionally supportive home office environments.

BUDGET: € 7.480,00

To develop virtual environments and perform experimental tests considering a VR-based methodology following equipments are required. The HTC system will be used to design, develop and test the virtual environments and to perform experiment with a high level of interactivity, allowing more realistic scenarios. With the facial tracker system, facial expressions can also be acquired. Meta Quests HMD will be used as stand-alone devices for intensive data collection in less interactive experiments also considering biosensors integration. A portable computer and a monitor will be also needed for development and data collection purposes. Main results will be presented on international conferences on Human Factors and Ergonomics area.

- 1 HMD HTC VIVE PRO 2 - Full kit (€1500,00), 1 HTC wireless adapter kit (€350,00), 1 HTC VIVE Facial Tracker kit (€150,00), 1 HMD Meta Quest 3 kit (€700,00) 1 Meta Quest Link cable (€80,00), 1 Brainsaver Biosense full pack kit (€550,00), Gelled Self-Adhesive Disposable Ag/AgCl Electrodes (100 unds) (€100,00), Portable computer Razer Blade 15 | Intel Core i7 12800H | Nvidia RTX 3070 Ti (€1800,00) and Monitor Gaming LG 27GN650 (27" - 1 ms - 144 Hz - AMD FreeSync Premium) (€250,00), Mission for data collection and Divulgation of projects results (€2000,00)