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Enhancing Patient Recovery And Well-Being: A Neuroarchitectural Analysis Of A Brazilian Philanthropic Hospital

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Abstract:
Background*: Integrating applied neuroscience in architecture, referred to as neuroarchitecture, elucidates the relationship between the built environment and its influence on human behavior. This article aims to provide a technical overview of neuroarchitecture in the hospital setting, using a Brazilian philanthropic hospital as the unit of analysis.*
Materials and Methods*: The research methodology adhered to the principles of a typical case study, employing two primary data collection techniques: (1) direct documentation and (2) observation. Specifically, the following methods were used: 1) Architectural and basic health projects (PBA) for the areas studied within the hospital; 2) Photographic records: capturing comprehensive information through photographs of the environments; and Written records: noting observations of the architectural spaces based on visual analysis.*
Results*: The results indicated that despite ongoing renovation efforts, the hospital spaces do not fully integrate the principles of neuroarchitecture. More specifically, it was demonstrated that both updated and non-updated environments deviate from scientific research on neuroarchitecture in certain defined criteria. However, it is noteworthy that there has been a significant improvement in the environmental conditions following space updates, particularly regarding elements such as color, lighting, and layout.*
Conclusion: *The study concludes that while updates have improved certain hospital environments, comprehensive renovations informed by neuroarchitectural principles are essential for optimal patient recovery and well-being.*
Keyword*: Neuroarchitecture; Humanization of Hospital Spaces; Environmental Psychology; Hospital Infrastructure; Hospital Management.*

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I. Introduction

Hostile by nature, hospital environments must be studied and humanized to create healthier spaces that promote well-being, aiding in the treatment and recovery of patients (Frizero, 2018). According to the World Health Organization (WHO), "health is a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity" (WHO, 2014). In this context, neuroarchitecture can significantly contribute to the humanization of spaces, benefiting overall health (Frizero, 2018).

Generally, research linking health to architecture focuses on identifying the origins of certain diseases, such as the constant exposure to excessive noise, which can increase blood pressure and affect adolescent neural development, or the disruption of circadian rhythms caused by insufficient exposure to natural light during the day (Coburn, Vartanian, & Chatterjee, 2017). However, according to these authors, some studies focus on how the design of the built environment can affect mental and physiological health. Examples include a patient's anxiety in a hospital, the desire to learn in a school, and the comfort and security of a home, all of which can influence a person's experience in the built environment.

The connection between neuroscience and architecture, termed neuroarchitecture, defines the relationship between the built environment and its influences on human behavior (Paiva, 2018). Neuroscience studies reveal different patterns of brain function, but genetic, cultural, and individual experiences make each person unique. Thus, the same environment can have different effects on different people, highlighting the importance of identifying the target audience to successfully apply neuroarchitecture.

Several studies worldwide demonstrate the development of neuroscience in conjunction with architecture, yielding significant results. In Thailand, a group of architects developed a design project in 2017 for the Ekachai Children's Hospital. The design process focused on creating colorful, arched environments, using colors to provide a comforting and welcoming atmosphere for children, filled with animals and clouds to offer a pleasant experience (Integrated Field Architects, 2020). Another study conducted at a Rehabilitation Center in Røros, Norway, concluded that unobstructed views of the natural environment positively impacted patients' physical and mental recovery (Raanaas, Patil, & Alve, 2015).

Given this background, the key research question is: How are the principles of neuroarchitecture being implemented in the context of philanthropic hospitals? To address this question, this research aimed to provide a technical overview of neuroarchitecture in the hospital context, using a philanthropic hospital founded in 1979 as the unit of analysis.

The literature on this subject has been growing in recent years; however, many questions about neuroarchitecture remain unanswered. For example, Djebbara et al. (2022) developed a review on a psychobiological framework describing how environmental characteristics can lead to automated sensorimotor responses through underlying neurophysiological mechanisms of attention. Other studies have explored the emotional influence of different geometries in virtual spaces using neurocognitive examinations (Shemesh et al., 2022); the effect of classroom lighting on university students' memory (Castilla, Higuera-Trujillo, & Llinares, 2022); mentalization network dysfunctions in patients with schizophrenia compared to healthy controls through dynamic causal modeling and an interactive social decision-making game based on neuroscience (Bitsch et al., 2021); the impact of learning space design on attention and memory from a neuroarchitectural approach (Llorens-Gámez et al., 2022); and the study of social complexity and brain evolution - insights from the neuroarchitecture and genome of ants (Traniello, Linksvayer, & Coto, 2022), among others.

It is important to note that the environment can provoke behavioral aspects in humans based on its characteristics. Physically, senses can be easily stimulated by aspects related to acoustic and thermal comfort, spatial luminosity, and ergonomics (Villela & Ely, 2020). Psychologically, senses can be stimulated by colors, sounds, smells, textures, etc. Therefore, a well-designed architectural project provides relaxing stimuli, especially for those more sensitive to the environment. Additionally, a project that understands the real needs of its users promotes the execution of activities and encourages space appropriation by its users (Villela & Ely, 2020).

II. Material And Methods

A quantitative research approach was employed, characterized as descriptive concerning its specific objectives. The study aims to conduct a technical analysis of various hospital spaces, comparing them with the principles of neuroarchitecture. Data collection for the analysis was carried out through the observation of hospital environments.

Research Context

To address the general objective proposed in this dissertation, a study was conducted in a hospital institution. The selection criteria for the study site were defined as follows: a) it must operate as a healthcare institution; b) it must provide regionalized services with a high patient flow and be philanthropic in nature. Accordingly, a hospital located in the state of Santa Catarina, Brazil, was intentionally chosen for accessibility. Recognized as a general hospital, it is maintained by a philanthropic institution. Founded on February 21, 1979, in a municipality with an estimated population of 80,017 inhabitants (IBGE, 2021), the hospital currently has 124 long-term recovery beds and an additional 20 beds in the Intensive Care Unit (ICU). Its staff comprises 350 individuals, distributed across various sectors: medical care, nursing team, administrative, support services (nutrition and dietetics, laundry, cleaning), and multi-professional assistance services (psychology, social services, nutrition, physiotherapy). Additionally, it offers emergency and urgent care and hospitalization in various specialties such as Anesthesiology, Angiology, Internal Medicine, Pediatrics, General Surgery, Vascular Surgery, Thoracic Surgery, Endocrinology, Psychiatry, Ophthalmology, Cardiology, Gastroenterology, Nephrology, Neurology, Neurosurgery, Obstetrics, Otorhinolaryngology, Orthopedics and Traumatology, Radiology, and Urology. The main examinations provided are imaging, such as X-rays, Ultrasound, and Tomography.

The average number of monthly services includes 500 clinical and surgical hospitalizations, 4,000 radiodiagnostic examinations, and 2,500 emergency department visits. The latter has streamlined its services through a Triage system implemented at the end of 2008, prioritizing more urgent cases.

Data Collection and Instruments

Data collection was conducted using two techniques: (1) direct documentation and (2) observation. The following methods were used:

1. Architectural and basic health projects (PBA) for the areas studied within the hospitals.
2. Photographic records: capturing comprehensive information through photographs of the environments; and
3. Written records: noting observations of the architectural spaces based on visual analysis.

The research protocol for verifying the adequacy of the infrastructure was developed based on the proposal by Soares Neto et al. (2013), which presents the levels of infrastructure and the items comprising each level. The research protocol outlined involves evaluating various hospital environments based on seven elements: colors, aromas, sounds, forms, biophilia, lighting, and layout. Each element is assessed for its adequacy using five criteria: Does Not Meet, Partially Meets, Satisfactory, Fully Meets, and Not Applicable. This structured approach allows for a comprehensive evaluation of the hospital spaces, ensuring a detailed analysis of their alignment with the principles of neuroarchitecture, focusing on aspects that influence patient comfort and well-being.

According to the protocol, five criteria were selected to observe the adequacy of the described elements:

- Does Not Meet: marked when the element is completely absent.
- Partially Meets: marked when the element is present in a superficial manner where hygiene and comfort issues are not efficiently addressed.
- Satisfactory: marked when the element is present and maintained adequately.
- Fully Meets: marked when the element is fully addressed with hygiene, comfort, and both material and human

Data Analysis

This research employs the content analysis technique proposed by Bardin (2011), which aims to identify categories emerging from the literature. The technique is executed in three stages: pre-analysis, material exploration, and results treatment. The data analysis was conducted using both traditional manual methods and supported by OpenAI. The following sections present the key findings and discussions from this study.

III. Results

Data collection was conducted through direct documentation analysis of architectural and health projects in the areas under study, as well as through the collection and analysis of photographs of the environments and written records based on observations of the architectural spaces. Eleven environments where patients and healthcare professionals reside were selected for this study. Based on theoretical references, seven physical space elements were analyzed, following the methodology presented by the Brazilian Academy of Neuroscience and Architecture (NEUROARQ Academy). These elements are colors, aromas, sounds, forms, biophilia, lighting, and personalization (layout). After defining the methodology and collecting the data, the materials were analyzed to achieve the first specific objective, which was to describe the hospital environments.

Since 2015, a general renovation of the Hospital environments has been ongoing, progressing slowly due to limited resources, and it has not yet been completed. The initial analysis identified environments that have already undergone renovation, those currently under construction and not usable for the study, and the original environments that have not been updated in terms of materials, equipment, and functions. It is important to highlight that, at first glance, it might be assumed that the original environments are entirely inconsistent with the research on neuroarchitecture, in contrast to the recently updated environments. However, it was demonstrated that both updated and non-updated environments deviate from scientific research on neuroarchitecture in some of the defined criteria.

To meet the second specific objective, the environments were analyzed and classified into levels according to the proposal by Soares Neto et al. (2013). For this stage, five criteria were used to observe the adequacy of the seven elements in the selected environments: does not meet, partially meets, satisfactory, fully meets, and not applicable. Additionally, to better understand the spatial reality and the level of adequacy to the seven physical space elements, scores were assigned to the previously established criteria: 1 point for "does not meet"; 2 points for "partially meets"; 3 points for "satisfactory"; and 4 points for "fully meets". The "not applicable" criterion was not scored as it does not characterize the physical space.

Table no 1: Summary of the Infrastructure Analysis of the Hospital

Environment	*Elements*	*Level of Adequacy*					**Total Score**
		Does Not Meet	Partially Meets	Satisfactory	Fully Meets	Not Applicable |	
General Reception	Colors				4		**23**
	Aromas					0	
	Sounds			3			
	Forms				4		
	Biophilia				4		
	Lighting				4		
	Layout				4		
Emergency Reception	Colors			3			**18**
	Aromas					0	
	Sounds			3			
	Forms			3			
	Biophilia		2				
	Lighting			3			
	Layout				4		
Pediatric Observation Room	Colors				4		***23***
	Aromas	1					
	Sounds			3			
	Forms				4		
	Biophilia			3			
	Lighting				4		
	Layout				4		
Adult Observation Room	Colors			3			***15***
	Aromas	1					
	Sounds			3			
	Forms		2				
	Biophilia	1					
	Lighting			3			
	Layout		2				
Inhalation Room	Colors		2				***12***
	Aromas					0	
	Sounds		2				
	Forms		2				
	Biophilia	1					
	Lighting			3			
	Layout		2				

Outpatient Clinic (Medications)	Colors			3			***17***
	Aromas					0	
	Sounds		2				
	Forms			3			
	Biophilia		2				
	Lighting				4		
	Layout			3			
Adult Collective Ward	Colors		2				***11***
	Aromas	1					
	Sounds		2				
	Forms	1					
	Biophilia	1					
	Lighting		2				
	Layout		2				
Children's Collective Ward	Colors		2				***11***
	Aromas	1					
	Sounds		2				
	Forms	1					
	Biophilia	1					
	Lighting		2				
	Layout		2				
ICU São Rafael	Colors		2				***12***
	Aromas					0	
	Sounds		2				
	Forms			3			
	Biophilia	1					
	Lighting		2				
	Layout		2				
UTI São Miguel Arcanjo	Colors			3			***20***
	Aromas					0	
	Sounds				4		
	Forms			3			
	Biophilia			3			
	Lighting				4		
	Layout			3			
Induction and Post-Anesthetic Recovery Room	Colors			3			***19***
	Aromas	1					
	Sounds			3			
	Forms				4		
	Biophilia		2				
	Lighting			3			
	Layout			3			

Source: Research Data

Note: Blank for renovated or under renovation environments / Gray for environments in the original configuration

Based on the analysis of the table and the corresponding scores, it can be observed that:

- There has been a significant improvement in the condition of the environments concerning the updating of spaces, particularly in the elements of Colors, Lighting, and Layout.

- The General Reception and the Pediatric Observation Room scored the highest in the analysis. Specifically, as a long-term stay environment, the Pediatric Observation Room provides a better contribution to the patient's prompt recovery, according to architectural neuroscience studies.
- As expected, environments that have not undergone updates or renovations scored the lowest. However, the Inhalation Room (already renovated) scored very close to the original environments. Additionally, it is noteworthy that the Adult Observation Room, despite being updated, scored below the overall average (16.54 points), remaining very close to the non-renovated environments, which, according to studies, hinders patient recovery.
- The collective inpatient wards, both adult and pediatric, as well as the São Rafael Intensive Care Unit, which are original environments of the hospital and have not been updated, scored the lowest. Since these are environments where stays are prolonged, it can impair the additional reinforcement that neuroarchitecture can provide for patient recovery.
- The element "Aroma" is not utilized in any analyzed environment as an accelerator in therapies.
- The element Biophilia is minimally explored in both original and updated environments, which, according to research, is one of the strongest agents within neuroarchitecture in aiding patient recovery.

Thus, it can be concluded that the completion of updates and renovations will be of great value for the implementation of the seven physical space elements, according to the methodology presented by the Brazilian Academy of Neuroscience and Architecture (NEUROARQ Academy). However, as analyzed and previously mentioned, updating alone does not incorporate these elements. It is necessary for a collective effort by managers, architects, executors, and other involved professionals to understand the importance of studies in Neuroscience applied to hospital architecture to optimally adapt these environments.

IV. Discussion

Architecture can greatly contribute to the treatment and overall well-being of patients, as well as the professionals working on the front lines. "Spaces can make people happier, and the social, physical, and spiritual well-being of human beings should be the outcome of any project" (Pompermaier, 2021, p.4).

There is no one-size-fits-all formula for designing hospitals or other healthcare facilities. The requirements are extensive, encompassing aspects such as workflow, biosafety, functionality, among others. Additionally, the needs of the contractors (whether public or private), health regulations, investment value, and patient needs must all be addressed, typically in that order. However, it is crucial to prioritize patient needs above other requirements.

The implementation of neuroscience applied to architecture, particularly in the hospital sector, must be approached with caution and requires further study. Neuroarchitecture emphasizes the impact of the built environment on the human brain and behavior, highlighting the importance of thoughtful design in healthcare settings. According to Paiva (2018), "individuals are unique according to their genetics, culture, and life experiences. Neuroarchitecture identifies certain reactions that the brain has to specific stimuli in neutral situations" (p. 138). This means that people perceive and respond to stimuli differently, which is a fundamental aspect of human reality. Recognizing this allows for a deeper and more empathetic understanding of the various perspectives and reactions humans may have towards their surroundings.

Based on the results of this study, several key observations can be made:

- Improvement in Updated Environments: There has been a significant improvement in the condition of hospital environments following updates, particularly in elements such as Colors, Lighting, and Layout. These improvements align with the principles of neuroarchitecture, which suggest that such elements can enhance patient recovery and well-being.
- High-Scoring Environments: The General Reception and Pediatric Observation Room scored the highest in the analysis. The Pediatric Observation Room, as a long-term stay environment, contributes positively to patient recovery according to architectural neuroscience studies.
- Low-Scoring Environments: Environments that have not undergone updates or renovations scored the lowest. Surprisingly, the Inhalation Room, despite being renovated, scored similarly to original environments. The Adult Observation Room, even after updates, scored below the overall average, indicating that merely updating a space is not sufficient; it must be aligned with neuroarchitectural principles.
- Critical Areas: The collective inpatient wards and the São Rafael Intensive Care Unit, which have not been updated, scored the lowest. These are critical areas where prolonged stays can benefit significantly from neuroarchitectural enhancements.

- Neglected Elements: The element "Aroma" is not utilized in any analyzed environment as a therapeutic accelerator, and Biophilia is minimally explored. Research indicates that these are among the most influential factors in neuroarchitecture, suggesting an area for significant improvement.

The completion of ongoing updates and renovations will be highly beneficial for the implementation of the seven physical space elements as outlined by the NEUROARQ Academy. However, updating alone is insufficient. A collective effort from managers, architects, implementers, and other professionals is essential to understand and incorporate the importance of neuroscience in hospital architecture, ensuring that environments are adapted in the best possible way to support patient recovery and well-being.

V. Conclusion

The study aimed to provide a technical overview of neuroarchitecture within the hospital setting, using a Brazilian philanthropic hospital as the unit of analysis. The findings indicate that while there have been significant improvements in the updated environments, particularly in elements such as Colors, Lighting, and Layout, many hospital spaces still fall short of fully integrating neuroarchitectural principles. Notably, the highest-scoring environments, such as the General Reception and Pediatric Observation Room, demonstrate the potential benefits of applying neuroarchitectural concepts to enhance patient recovery and well-being. Conversely, environments that have not undergone updates, such as the collective inpatient wards and the São Rafael Intensive Care Unit, scored the lowest, underscoring the necessity for comprehensive renovations that align with neuroarchitecture.

Moreover, the study reveals that certain elements, such as Aroma and Biophilia, are largely neglected, despite their proven efficacy in promoting patient recovery according to neuroarchitectural research. This highlights a significant area for improvement. The results emphasize that while updates and renovations are crucial, they must be informed by a thorough understanding of neuroarchitecture to create truly therapeutic environments. Therefore, a multidisciplinary approach involving managers, architects, and healthcare professionals is essential to successfully implement neuroarchitectural principles in hospital settings, ultimately prioritizing patient needs and fostering a holistic approach to healthcare design.

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