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Sensory experiences in healthcare architecture: A comprehensive literature review

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Abstract

Throughout history, hospitals had been treated as sterile places used exclusively for providing medical treatment to patients. Little attention was however paid to the different ways those spaces can affect people occupying them, more specifically, through the senses. The things patients see, smell, touch, or feel all affect their well-being, leading to either an accelerated recovery, or prolonged hospital stays. Furthermore, besides a plethora of research showcasing the potential of incorporating sensory elements into healthcare architecture, the results have not been integrated into concrete examples to their full potential. The purpose of this review is to identify the effects of certain sensory elements, investigate the ways in which they had been incorporated into healthcare architecture, and recognize gaps in existing literature. Additionally, this review aims to propose ideas for further research in order to enrich the existing research connecting the senses with architecture.

Keywords: Evidence-Based Design; Healthcare Architecture; Sensory Design; Healing environments

1. Introduction

Throughout history, the environments we inhabit have played a quiet, but very powerful role in the shaping of our emotions, well-being, and behavior– an influence that becomes even additionally significant within spaces that are dedicated to healing, where weak, vulnerable patients rely on the environment surrounding them. Although architecture is often regarded as a science rooted in engineering and aesthetics, its close ties with medicine become undeniable when we realize how thoughtfully planned spaces can have a direct impact on physical recovery, psychological resilience, and the overall health outcomes of those in need.

Long-term exposure to the disagreeable built environment can have negative effects on both physical and mental health, leading to multiple problems, including heightened anxiety, depression, stress, and chronic illness [1]. These negative effects highlight the urgency of reshaping the built environment into spaces that actively contribute to healing. In that sense, the concept of healing architecture aims to turn the potential shortcomings of the built environment into deliberate therapeutic advantages. Hospitals often neglect the needs of patients, which manifests in a range of spatial design and arrangement features, from intense neon lighting from above, over lack of seating areas, to space with no outside view, all of which makes the patients' condition worse [2]. This is where the impact of architecture has on people plays a crucial role. In his book ' Attunement: Architectural meaning after the crisis of modern science', Pérez-Gómez pays special attention to the neglect of architecture's key role in assisting to maintain our well-being [3]. When patients who are already fighting an illness are presented with even more challenges stemming from a lack of proper hospital design and neglect of their needs, their problems can multiply. This neglect highlights the urgency to reshape the design of healthcare buildings in order to prioritize the well-being of patients. For example, Shumaker demonstrates that patients who are under additional stress require assistance from others, are less likely to process their surroundings, and prone to information overload [4]. Such findings underscore the value of incorporating psychological support into

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architecture. Although it poses an important role in their recovery, medical support is not the only vital requirement for patients staying in hospital rooms. The psychological aspect is an important one to take into consideration as well.

To make up for the shortcomings in the current design and address these challenges, researchers and architects have turned to biophilic design. The principles of biophilia offer guidelines to foster healing by transforming sterile clinical spaces into therapeutic environments. One of the promising approaches to suppress these shortcomings in planning is in fact biophilic design, which uses the connection of humans with nature. The term *biophilia* was coined by Erich Fromm. It is defined as 'love of life', showing the psychological orientation towards everything that is vital and alive [5]. According to Ulrich, the physical surroundings within healthcare facilities have an intense effect on the psychological and emotional state on its users, which directly have an effect on the physical health, too [6]. This poses a strong argument that architects have the ability to aid patients in their recovery. Although the majority of studies in the past focused on variables that have a negative effect on health, like the quality of indoor air or toxic materials, not a lot of research focused on the incorporation of natural elements into the indoor environment via biophilic design [7]. As noted by Marselle et al, newer studies showed that biophilic design environments that are appealing to visual preferences can alleviate negative effects [8]. For instance, Sharam et al. found that including natural elements within indoor environments has a positive effect on well-being and health, while reducing negative effects [9]. Together, these studies suggest the growing consensus that even subtle traces of nature– whether olfactory, tactile, or visual– could measurably improve the well–being of patients.

Despite the fact that the majority of research focused on diseases and their causes, it is of great importance to talk about health, and the numerous factors that have a positive effect on health. This was the hypothesis of Antonovsky. Aaron Antonovsky was an American sociologist who focused on the relation between stress and well–being. He coined the term *salutogenesis*. According to Antonovsky, the salutogenic approach could be the only comprehensive theory of promoting health, highlighting this theory as a powerful tool to determine the impacts of design on health [10]. In contrast to pathogenesis, which focuses on the origins of diseases, salutogenesis focuses on the factors that promote well-being and health, as noted by Mittelmark & Bull [11].

One of the biggest advantages of salutogenic design approaches is that it does not require the need to understand any illness that patients are facing, besides the basics that are covered by environmental medicine. Golembiewski supported Antonovsky's theory by additionally mentioning that it provides an accessible logic to determine the well-being benefits of design [12]. The salutogenic theory is not an alternative to medicine. According to Antonovsky, it has the ability and view that other ways of understanding health lack, as a theory. Salutogenic interventions are efficient because they inform environments design to accelerate the natural process of healing, since they are health oriented. Furthermore, according to Frankl these interventions promote health and provide a view into social approaches to complicated health problems [13]. Although universal accessibility aims to create spaces that are generally free of obstacles for all users, often benefiting many features like ramps useable by people who use wheelchairs, strollers, or even skateboards, inclusive design focuses on addressing the needs of individuals with the most challenging issues with accessibility. The salutogenic approach recognizes that solutions designed for extreme cases often provide even more advantages for the wider population, as recognized by Keates & Clarkson [14].

The integration of biophilic with salutogenic principles exemplifies a holistic transition in healthcare design, moving far beyond symptom management to promote well-being. A design guideline which combines salutogenic and biophilic principles to utilize therapeutic effects of nature in lowering patients' depression, pain, distress, and anxiety was proposed by Abdelaal, M. S., & Soebarto, V. [15]. This is one of the examples of how these principles are growingly being recognized in healthcare building design recently. In the past, the practice of design and health used to be the aim of medical design professionals. Recently, the growing demand for wellness influenced the field of architecture, making this practice a domain of architectural designers, too. Contemporary architectural practice has increasingly prioritized the intentional design, refinement, and evaluation of built environments, with a focus on quantifying their therapeutic potential through empirical analysis of patient rehabilitation outcomes. Scholarly investigations, such as the ones by DuBose et al. reveal that these spaces foster a holistic integration of physiological and psychological well-being, thereby advancing the theoretical and practical framework of 'healing environments' as a critical design paradigm [16].

After the early work of Ulrich in the 1980's, a plethora of design factors were linked to increased health outcomes and the development of therapeutic spaces in healthcare settings [17]. These theoretical and guidelines present the foundations for targeted sensory interventions, explained in more detail further.

2. Method

This study consists of a comprehensive literature review analyzing existing literature regarding the effects of senses,

their potential, and their incorporation into architectural practice, with a focus on healthcare architecture. Data was obtained from databases including Google Scholar, PubMed, and Scopus. To get a variety of results, keywords regarding architecture, healthcare, biophilia, and sensory design were used. The inclusion criteria consisted of mainly recent studies wherever possible, except certain older research that is crucial in the field. Studies which were old, unreliable, or consisted of complex language for the average reader were excluded. Additionally, research consisting of certain medical terms was translated into the context of architecture. In total, roughly 100 papers were screened, with 81 being selected for the final review. Such method presented a variety of results crucial for the understanding of the topic.

3. Results

3.1. Visual effects on health

Throughout history, it has been evident that architecture mainly focused on visual elements, using sight as the main sense through which the environment is not only experienced, but also designed [18]. According to Thampanichwat et. Al., the visual stimuli being a focal point is apparent in the way in which architectural elements are designed, with the visual ones being the most studied ones [19].

The use of colors poses an important part of architectural design. Studies have shown that colors have the ability to evoke certain emotional responses, as noted by Zhu et al. (2024). There is a plethora of the effects colors have on the psychological aspect of humans, directly affecting their emotions and mental health. A carefully chosen color scheme has the ability to create a sense of comfort [20]. This approach is important for patient recovery. Certain colors, for instance blue, are shown to be comforting. Similarly, orange is seen as an inviting and encouraging color [21]. The colors of patient rooms have the ability to accelerate recovery by reducing anxiety and elevating mood, which can set guidelines to the design of hospital rooms to foster the well-being of patients. As noted by Desty et. Al., patients in colored rooms reported better mood and quality of life, as opposed to the ones in traditional rooms [22].

Despite colors, the effects of shapes on the emotional state have also been identified. Studies done by cognitive neuroscientists have shown that humans have a natural preference towards curvatures. Curvilinear forms are typically rated as more approachable, as opposed to rectilinear, whether it is in the internal environment [23], or the furniture within the environment [24]. An interesting observation about angular forms related to interior design was also made. According to Saldago-Montejo et al., angular forms, especially when they are pointed downwards or towards people, are more likely to trigger a response of avoidance [25]. Looking at angular shapes, even for a short amount of time triggers a fear response in the amygdala, which is responsible for our emotions [26]. These studies show that even simple things like shapes that we see as pure design elements have an important effect on our perception, and in the end, our well-being. In order to create a holistic space, architecture has recently been moving towards a multisensory approach that recognizes the importance of applying other senses into design, as highlighted by Skaza [27].

3.2. The effects of other senses on health

Besides nature itself, it has been shown that every single sensory channel carries certain therapeutic benefits. The positive effects of colors, light, and hospital environment on the body and the illness, not just on the minds of patients, have been talked about by Florence Nightingale in 1859. Despite the fact that a growing body of literature demonstrated a strong relation between the increase in the effectiveness of treatment and the environment, not a lot of attention is paid to the quality of design in hospitals [28].

The effects of light on patients have been discussed in a number of research. While light is a critical factor, its interplay with other sensory stimuli still remains underexplored. For instance, Walch et al. found natural light reduces chemotherapy stress [29], but could combining light with nature sounds or perhaps even smells amplify this effect? Similarly, structures filled with light have the ability to influence melatonin, dopamine, serotonin and the L–Dopa levels, as witnessed by Deguchi & Axelord [30]. Finally, patients who spent their recovery time after a spinal surgery by lying in wards with a lot of sunshine used 22% less analgesic medicine and reported lower stress levels, as opposed to the same type of patients who were lying in darker wards [31].

Transitioning from light to sound, the auditory environment also shapes the outcomes of patients. In terms of sound within architectural design, discussions tend to focus on minimizing and avoiding unwanted noise, as noted by Owen [32]. This is a strong argument that architecture of healthcare facilities needs to pay more attention to the different ways certain sounds can be used to promote the healing of patients. The majority of research is mainly focused on a single aspect of sound– noise, or 'unwanted sound' [33]. This issue is highlighted by Schafer, who claimed that 'modern architects are designing for the deaf', implying the lack of consideration of noises within design [34]. Failure to consider

the auditory factors as a whole within the design of buildings might help to explain a certain part of the world-wide health crisis that is associated with noise pollution affecting not just our sleep, but also health and overall well-being, as noted by Owen [32]. This shows a strong correlation between noises and health, and in the end– the recovery of patients. The duality of sound, harmful versus therapeutic, suggests that auditory design must balance noise reduction with intentional soundscaping. For example, Medvedev et al. demonstrate that nature sounds accelerate stress recovery, proving that pleasant natural sounds aid recovery from stress, yet hospitals rarely implement such findings [35]. An important positive improvement in the state of patients can be seen when the noise levels are minimized [36]. Furthermore, it was noted by Hagerman I et al. that survival and better healing in ICU patients are registered after improving the sound levels and minimizing the impact of noise sources [37]. As noted by Shumaker S A & Reizenstein, high sound levels and certain sounds have a negative impact on patients by making them feel like they are lacking control, increasing worry, anxiousness, and nervousness [38]. Qualitative studies describe exposure to natural environments as a positively regarded, multi-sensory experience. Following qualitative interviews with 20 wildlife tourists, Curtin reported that participants experienced heightened sensory awareness after wilderness trips to locations in the USA and Spain [39]. Similarly, Fredrickson found that a sample of 12 women described direct experience of the sounds of nature as a particularly meaningful aspect of wilderness trips to Minnesota and Arizona [40]. Although these studies show that natural sounds play an important role in the perception of natural environments, the number of participants is relatively low. Furthermore, they do not talk about the effects of sounds in healthcare settings. Supplying nature sounds alongside visuospatial nature stimuli can enhance positive appraisals of settings, including perceived restorativeness and preference [41]. Qualitative research further indicates a relationship between positive effects and the presence of natural sounds. In semi-structured interviews, participants associated the sounds of nature, such as wind, water and birds, with restorative experiences like pleasure, relaxation, and escape from everyday concerns [42]. Studies like those of Jo et al. highlight that exposure to sounds from forests or oceans reduce physiological arousal, such as heart rate and respiration frequency, compared to urban noise [43]. These findings indicate that nature's soundscapes are more restorative than those of built environments. A growing body of research also demonstrates the restorative outcomes associated with listening to the sounds of nature, aligning with evidence that visuo-spatial experiences of nature can benefit psychological well-being [44]. Access to green and blue spaces has been linked to positive mental health outcomes and chronic health condition management [45].

In terms of the olfactory system, it is evident that there is not a lot of research available that talks about the relation smells have on health. Smells are present in all environments, yet they play a crucial role on not just creating a pleasant atmosphere but also affecting people in various ways. There is evidence that the olfactory aspect of design has the ability to affect behavior. According to De Lange et al., a hint of citrus in the air engages people in cleaning behavior [47]. As noted by Candau & Schaal, an abundance of evidence has only recently shown the relations between the olfactory system with manifold benefits [46]. Examples include mood [48], metabolic health [49], autoimmune conditions [50], and behavior [51]. The usage of certain smells to improve well-being and health is not a new trend– it has been documented throughout history with traditional and contemporary techniques used in aromatherapy [52]. Senses firstly travel to a brain region known as the thalamus. Its role is to process the information about the things we touch, see, or hear, to the rest of the brain [53]. It is of great importance to mention that unlike other senses, smells travel directly to the limbic system which houses the amygdala, where emotions are processed, as well as the hippocampus, where the formation of memory and learning occur [54]. This strong relation between emotions and smells can be observed through the emergence of depressive episodes following the development of olfactory disorders [55]. In a similar way, memories that are olfactory based can induce a strong emotional response once triggered [56]. Evidence shows that smells that are connected with nature have the ability to improve well–being. Through their investigation of therapeutical potential in various landscapes, Finlay et al. noted that participants enjoyed the smell of herbs, while having the desire to be immersed in smells [57]. Furthermore, Hedblom et al. showed that smells have a better ability of reducing stress than visual elements through a virtual experiment [58]. Horticulturalists which specialized in the therapeutic effects of plants have reported both physiological and psychological benefits of certain plant smells, including geraniums [59]. Smells that are connected to memories have the ability to affect emotions, stress, as well as physical indicators like stress. Smell is one of the senses that is rarely included in architectural design, even though it is the sense used to observe the environment. As noted by Laohakangvalvit et al., aromas could foster calming effects, and improve mental health, which has a direct effect on the physical well–being of patients, leading to quicker recovery, especially when combined with tactile design elements and visual patterns [60]. In a similar way, researchers have shown that scents associated with aromatherapy, like lavender, have been shown to have beneficial effects on those exposed to them [61].

3.3. Research on multisensory design

Numerous clinical studies now confirm sensory based design strategies and their effects. Within significant studies, one of the first and most important studies about the effects of senses on patient's recovery was examined in 1984 by Ulrich. He examined the medical records of patients who underwent cholecystectomy between 1972 and 1981 in order to

determine whether being assigned to a room with a view of a natural setting could have any restorative effects. His study found that patients with windows overlooking a natural scene had shorter postoperative hospital stays, received fewer negative comments, and required less potent analgesics compared to those patients in similar rooms with windows facing a brick building wall. More specifically, this research highlighted that exposure to nature and greenery reduced hospitalization time by 8%, underscoring the restorative potential of biophilic design in healthcare environments [62]. As Marcus and Barnes noted, it has been shown that 95% of patients that were exposed to direct contact with nature reported manifold benefits, including positive thoughts, an increased ability to cope, and lowered levels of stress [63]. The effects of indoor vegetation on the reduction of stress in hospital rooms have also been researched. As noted by Schmid et al., the inclusion of natural elements in psychiatric environments could improve av overall state of well-being in patients [64]. Similarly, results of research by Dijkstra et al. have shown that the presence of indoor vegetation led to a significant reduction of stress levels in patients. Additionally, feelings of comfort and an improved mood were also noted [65]. In a study by Ulrich et al., the impact of biophilic garden views on the reduction of aggressive behavior in psychiatric ward patients was examined [66]. It was found that patients who had a view onto the biophilic garden had much lower levels of aggressive behavior when compared to patients without such view. This study showed that biophilic design has the ability to enhance the mood of patients, additionally highlighting the importance of incorporating such design within hospitals to improve patient's well-being and speed up their recovery. Park, S. H. and Mattson, R. H. evaluated whether plants in hospital rooms have certain therapeutic influences on patients who underwent surgery by performing a randomized clinical trial. Ninety patients recovering from an appendectomy were randomly assigned to hospital rooms with or without plants. It was found that patients in hospital rooms with plants had significantly fewer intakes of postoperative analgesics had higher satisfaction about their rooms, more positive physiological responses, and more positive feelings [67]. Kim had researched the effects that natural plants have on psychological and physiological measures, including EEG data. Their research found that looking at natural plants led to important increases in theta power, as well as a decrease in beta power in the occipital regions that are associated with attention and relaxation [68]. The findings of numerous research affirm the positive effects on physical and mental health through the inclusion of natural elements within built environments, particularly in hospital settings where the state of patients can be greatly impacted by environmental factors. The significance of an open ward atmosphere that encouraged patients' interaction with nature resulted in facilitating their healing by lowering their heart rate and blood pressure, as noted in a case study by El Messeidy [69]. Beukeboom et al. noted that the inclusion of natural elements within hospitals has the ability to not just increase the attractiveness of waiting rooms but also create a comfortable atmosphere that has a positive effect on the well-being of patients [70]. According to White et al., although the reduction of stress is greater in situ, stimulated natural experiences can also help reduce stress [71].

The environment surrounding us is interpreted using diverse senses, each of them having distinctive contributions to our everyday existence. Environmental psychology researchers have emphasized the influence sensory features of a built environment have on people [72]. It has been known for a long time that our health and well-being are affected by the sensory qualities of the environment in various settings, including healthcare buildings but homes as well [73]. Until recently, environmental psychologists have given little consideration to the question of the interaction of the senses and their common effect on humans. This neglect is especially important considering the fact that the natural and built environment, as well as the atmosphere of certain spaces, are by definition multisensory experiences [74]. In the context of architectural design of healthcare facilities, the understanding of this multisensory dynamic becomes key for the creation of environments that can positively affect the psychological and physical well-being of patients. The integration of different sensory experiences, like colors, smells, sounds, and textures, allows for the shaping of spaces that not only respond to functional needs, but also actively contribute to the process of recovery and overall experience of healthcare buildings users. Literature suggests that art, including videos of landscapes that acts as a distraction has a positive impact on pain [75]. As noted by Bayramzadeh et al., environments designed with the consideration of temperature, lighting, and noise have the ability to improve psychological and physiological well-being not just in patients, but also staff [76].

It becomes clear that almost all designs, including architectural designs, are made for only the visual sense. This affirms the importance of incorporating other senses into design as well. Finnish architect Pallasmaa recognized the multisensory aspect of buildings. He noted that we tend to scan our surroundings using our skin, nose, ears, and even tongue, as opposed to perceiving architecture as simply visual images [77]. The field of environmental psychology is mainly dominated by visual approaches. On the contrary, far less attention was given to the study of other senses and their qualities of the built environment, including auditory [78], tactile [79], and even olfactory [80]. Tactile elements in design are also often overlooked. In fact, the first moment of physical contact with a building usually occurs when we enter or leave. Pallasmaa explained this figuratively, stating that “The door handle is the handshake of the building” [77]. However, contact with a building is also made once inside a building, for example with the flooring [81], furniture, and even minuscule objects like the buttons of an elevator. These findings further support the idea that there is a strong relation between architecture and cognitive neuroscience. In recent years, the relations between architecture and

cognitive neuroscience have grown rapidly, given many psychological observations [82]. Such interventions have the ability to enhance psychological well-being and reduce anxiety in patients [83].

4. Discussion

Despite a plethora of research that indicates the positive effects of individual sensory elements, such as natural light, the sounds of nature or pleasant smells, there are significant gaps in literature when talking about the full, integrated approach to hospital design. There is a need for a direct application of the multisensory design principles in real life examples, as most practical applications remain limited to workshops. Putting these design principles into concrete examples is vital to enhancing the cognitive and social development of individuals with the help of architecture. Many authors, including Ulrich (1984) and Marselle et al. (2021) highlight the importance of individual elements, there is few research that tests the synergic effect of combining multiple senses. Researching an integrated approach which takes into consideration multiple senses, if not all, could result in important findings. Additionally, the majority of research focuses on non-clinical or work environments, while relatively few works directly investigate the application of these principles in hospitals. Such shortcoming should be taken into account when talking about healthcare architecture.

Another gap can be seen in the fact that the majority of existing literature user quantitative studies for measuring individual effects, but there is still a deeper qualitative analysis missing in order to understand the subjective perception of patients and their experience in a multisensory setting. Literature also rarely takes into consideration the interaction between different sensory channels– for example, how the combination of light and smells or sound and touch can additionally have an effect on the psychological state of patients and their recovery.

Therefore, although there does exist a strong basis that confirms individual positive effects, further research is needed that would:

- examine integrated, multisensory design in the context of hospital settings
- combine quantitative and qualitative approaches to obtain a complete picture of the effects of these elements
- take into consideration the long-term effects of multisensory design on the well-being and recovery of patients

With such approaches, the existing research on senses, architecture, and well-being can be expanded further. In a time where architecture is still seen as a passive agent consisting of static, cold elements, a different influx, which sees architecture as something perceived with the senses that have a direct effect on its occupants, needs to get more attention.

5. Conclusion

Based on the presented research, it is evident that the senses have significant potential, and do not represent a static part of human life. Furthermore, such potential can and should be taken into consideration by architects when designing buildings, especially healthcare buildings where vulnerable patients spend their time. This research highlights the importance of incorporating sensory elements into the design of healthcare buildings, and the dangers of their lack. Through the integration on such elements into design, architecture has the potential to serve as spaces that heal the spirit and body.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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