Table of Contents

Background and Related Work

Research

We observed that certain sensory stimuli have a calming effect on the human body and can help reduce stress, anxiety, and the perception of pain. The scents of orange and lavender, in particular, demonstrated a relaxing effect and contributed to an enhanced sense of well-being.

Additionally, it was observed that calm, familiar sounds as well as nature sounds such as rain, the sound of the ocean, or birdsong create a soothing atmosphere. These auditory stimuli can help alleviate feelings of anxiety and make pain feel subjectively less intense.

The results suggest that the targeted use of scents and soothing sounds can have a positive impact on both emotional and physical relaxation.

Introduction

Research shows that the environment in healthcare facilities has a significant impact on patient well-being and recovery. Sterile and impersonal environments can increase stress and anxiety, especially in children prior to medical procedures. Studies using the Modified Child Dental Anxiety Scale (MCDAS) report anxiety prevalence rates between 13.3 % and 29.3 % **[1]**.

Introducing calming visual elements such as nature imagery, colors, and familiar environments can help reduce psychological stress and improve emotional comfort. In this context, digital technologies such as projection systems and virtual reality are increasingly used to create immersive and engaging environments. These technologies aim to distract patients from anxiety, pain, and medical procedures, thereby improving the overall patient experience.

Concepts

Provide here all relevant concepts related to the topic(s) of the project

Healing environments in hospitals

According to the principles of Evidence-Based Design (EBD) intoruced previously, a “healing environment” is defined as a physical space where the interaction between patients, staff, and the environment actively results in positive health outcomes **[2]**. Rather than passive background for medical procedures, the physical setting is now more often recognised as both a “tool and healer” that can support the welness process through psychophysiological effects **[3]**. To transform sterile, standard clinical waiting rooms into a functioning healing environment, some core environmental and psychological factors must be adressed.

Sensory overload and mitigating surroundings stressors

The traditional concept of the healing environments relies on minimizing ambient stressors that causes anxiety. Hospitals and clinics are elementally filled with environmental stressors, including

unfamiliar medical equipment, harsh lightning, lack of privacy **[4]**. Excessive clinical noise from paging systems, alarms and voices are also source of distress **[5]**. In some clinical units, equipment noise levels can reach up to 90 dB(A), which is equivalent to the threshold where hearing loss can begin **[6]**. These uncontrolled acoustic environments disrupt rest, increase blood pressure, and heighten feelings of helplessness **[7]**. To effectively stop this sensory overload, spaces must be designed with acoustic comfort in mind. Providing sound-absorbing materials, such as specialized acoustic panels or ceiling tiles significantly reduces noise propagation and lowers the stress for bith patients and staff **[8]**, **[9]**.

Privacy and control

Another psychological contributor to hospital-induced anxiety is the patient's loss of control over their unfamiliar surroundings. When patients feel they have lost control over every sesnory input or task, it triggers cognitive, affective and physiological consequences that can strongly interfere with treatment and recovery **[10]**. Providing patients with the ability to take control over their immediate environment - such as adjusting lighting, temperature or sound - restores their autonomy and act as a powerful buffer against stress **[11]**, **[12]**. Additionaly, traditional waiting areas usually lack adequate privacy; for instance , overhearing clinica conversations at a reception desk is a frequently cited stressor **[13]**. Providing a semi-enclosed, private sanctuary shields the patients from the unpredictable nature of a shared waiting room, restoring a sense of security **[14]**.

Multisensory experience: Scent, Visuals, Light

An advanced healing environment utilizes multisensory, non-pharmacological interventions to regulate patient emotions, such as:

- Color and Light interaction:

The color and type of light around us have a big impact on how we feel **[15]**. Research shows that light that changes or moves creates much stronger emotional feelings than light that stays the same **[16]**. Scientists have found that using green or blue-green light along with slow, guided breathing - specifically one breath every 5 seconds - helps the body relax **[17]**. This effectively increases Heart Rate Variability (HRV) and quickly lowers feelings of stress or tension waiting in a room **[18]**. Additionally, looking at nature or pictures of landscapes is a great distraction that easily keeps people's attention and helps them feel more peaceful **[19]**.

- Scent stimulation

Our sense of smell is connected directly to the parts of the brain that handle emotions, so certain scents can quickly change how we feel. Studies show that smelling specific scents, especially orange and lavender oils, works like a natural way to relax the body **[20]**. When these smells are used in dental waiting rooms, they greatly lower anxiety and help patients feel much calmer and happier while they wait for their treatment **[21]**.

In summary, an effective healing environment must address these diverse sensory needs simultaneously. By integrating acoustic control, lighting, calming scents, and architectural privacy, a space can actively counteract the depersonalization and fear often felt in hospitals, calming the patient before they ever reach the doctor's room.

Digital distraction therapy

Digital distraction therapy is increasingly used in healthcare to help patients cope with stress, anxiety, and pain. The idea behind distraction therapy is to shift the patient's attention away from medical procedures or discomfort **[22]**. Examples include:

- Virtual Reality (VR) headsets which have been shown to significantly reduce anxiety and pain perception in pediatric patients during medical procedures **[23]**, **[24]**.
- Interactive walls and projection systems have been implemented in hospitals to create engaging environments that distract patients and improve emotional comfort **[25]**, **[26]**.
- Digital games and immersive environments have been explored as effective tools to increase patient engagement and reduce perceived stress in healthcare settings **[27]**.

These findings highlight the importance of distraction as a mechanism for reducing anxiety. However, many existing solutions rely on screens or wearable devices. This project builds on these insights by creating a more immersive, non-wearable environment that integrates distraction into the surrounding space.

Virtual reality/Smart glasses

Virtual Reality (VR) and smart glasses provide immersive or augmented visual experiences directly in the patient's field of view. VR technology is widely used in healthcare to reduce anxiety by immersing patients in virtual environments.

Al-Nerabieah et al. (2020) **[28]** evaluated the impact of VR eyeglasses in a dental waiting room and found that their use significantly decreased anxiety levels in children aged 6–10 years. While VR offers high levels of immersion, it requires wearable devices, which may be uncomfortable or impractical in some healthcare situations. VR demonstrates the strong impact of immersive environments on anxiety reduction. However, the reliance on wearable devices introduces limitations in hygiene, comfort, and usability. This project takes inspiration from the immersive aspect of VR, while eliminating the need for wearables.

Cocoon environments

Cocoon environments are designed to create a protected and calming space around the patient. The idea of a cocoon is to reduce the feeling of being in a clinical hospital environment and instead provide a sense of safety, comfort, and privacy. In healthcare design, a cocoon concept often uses visual elements, lighting, or digital technology to surround the patient with soothing stimuli. This can help reduce stress, anxiety, and sensory overload during hospitalization. Examples include:

- Immersive projection environments that transform spaces into calming scenes, such as nature or abstract environments, have been shown to reduce stress and improve emotional well-being in healthcare settings were successfully tested in this study **[29]**.
- Soft lighting systems combined with visual environments, such as natural or familiar imagery, can create a more relaxing atmosphere in patient rooms and improve emotional comfort were tested by this study **[30]**.
- Enclosed or semi-enclosed relaxation spaces can provide patients with a sense of privacy and safety, reducing external stimuli and contributing to lower stress levels were explored by **[31]**

These concepts form the foundation of the proposed solution. By combining immersion, multisensory

stimulation, and a semi-enclosed structure, the cocoon integrates the most effective elements identified in the literature. This allows the design to create a controlled, calming environment that enhances both emotional comfort and anxiety reduction.

Products

Market Analysis – Healing Spaces

Competitor Landscape There are several established companies focusing on transforming hospital environments through immersive and sensory design solutions.

Key Players

Direct Competitors

Philips Healthcare – Ambient Experience

What they do: Philips Healthcare **[32]** is a market leader in creating immersive healthcare environments by integrating dynamic lighting, video projection, and sound into treatment spaces such as Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) rooms.

Strengths: Highly professional and medically certified solution, seamlessly integrated into hospital architecture, with proven impact on reducing patient anxiety.

Weaknesses: Extremely expensive and primarily focused on diagnostic environments (MRI, CT rooms), making it less accessible for everyday patient rooms or long-term care settings.

Qwiek (Qwiek.up)

What they do: Qwiek **[33]** is a Dutch company that develops mobile projection systems designed for use in healthcare environments, particularly in elderly care and hospitals. The system projects calming visuals, such as nature scenes, onto walls or ceilings to create a more relaxing atmosphere for patients.

Strengths: Mobile and easy to use, allowing the device to be moved between rooms. The system is accessible and requires minimal setup, making it suitable for various healthcare settings.

Weaknesses: The device is a standalone floor unit, which takes up space in already crowded environments. In addition, the level of interactivity is limited, offering mainly passive visual experiences with minimal user engagement.

This solution demonstrates the potential of projection-based environments but lacks immersion and a sense of personal, enclosed space, which our cocoon concept aims to provide.

Indirect Competitors & Substitutes

SyncVR Medical

What they do: SyncVR Medical **[34]** is a Dutch company that provides Virtual Reality (VR) solutions for healthcare. Their platform offers immersive VR experiences designed to reduce pain, anxiety, and stress during medical procedures, particularly in pediatric and clinical settings.

Strengths: Highly immersive experience that effectively distracts patients from medical procedures. Proven to reduce anxiety and pain perception. The system is relatively portable and can be used across different departments.

Weaknesses: Requires wearable VR headsets, which raises hygiene concerns in shared environments. Some patients may feel uncomfortable or disoriented when using VR. In addition, setup and supervision are often required, making it less practical for continuous or large-scale use.

This highlights the limitations of wearable VR solutions in healthcare, reinforcing the need for immersive, non-wearable environments such as the proposed cocoon concept.

Projects

Market Trends

Evidence-Based Design (EBD)

Hospitals are increasingly designed based on scientific evidence showing that the physical environment influences patient recovery, stress levels, and overall well-being. Design elements such as lighting, color, and visual stimuli are used to create more supportive healing environments. An example of this approach can be seen in the Princess Máxima Center for Pediatric Oncology, where the environment is specifically designed to improve patient experience.

Research **[35]** shows that the physical hospital environment directly influences patient recovery, stress levels, and overall well-being.

Staff Shortages & Efficiency

Healthcare systems are increasingly facing staff shortages, creating a demand for solutions that can support patient care without requiring constant supervision. Technologies that help calm, distract, or engage patients can reduce the workload on healthcare professionals.

Design interventions and environmental solutions can reduce patient stress while simultaneously improving workflow efficiency, helping to relieve pressure on healthcare staff **[36]**.

Comparative Analysis

To determine the most effective solution for reducing anxiety in children, various existing technologies and approaches were analyzed and compared. This comparison focuses on key criteria such as immersion, comfort, hygiene, ease of use, and feasability in healthcare settings.

VR Headsets offer a highly immersive experience by completely blocking out the real world and placing the user in a virtual environment. This can help reduce anxiety and stress, and research **[37]** shows that VR can be effective in distracting children during medical procedures. However, VR also has a number of disadvantages. In shared environments such as waiting rooms, hygiene is a concern, as the headset must be cleaned after each use. Some children may also feel uncomfortable wearing a headset, especially if they are already anxious. Furthermore, the time required to set up and reset the device makes it less practical for multiple users.

Smart glasses or Augmented Reality (AR) glasses are an innovative solution that combines digital elements with the real world. They are lighter than VR headsets and allow the user to remain aware of their surroundings while still interacting with virtual content. On the other hand, this technology is still relatively expensive and has not yet been widely adopted in healthcare. The level of immersion is also lower than with VR, making this technology less effective as a distraction. Therefore, AR glasses are currently less suitable for these types of applications.

Projection-based environments create immersive images on walls or surfaces without requiring the user to wear a device. This makes them highly accessible, hygienic, and user-friendly for multiple children. However, the experience is less immersive compared to other solutions. Children remain aware of the waiting room, which can reduce the calming effect. Furthermore, there is a lack of a sense of a personal or protected space, which is important for children with anxiety symptoms.

Multisensory cocoon (our solution) combines various sensory elements, such as visuals, sound, scent, and gentle movements, into a single environment. It creates a semi-enclosed space that gives children a sense of security and reduces external stimuli. Compared to other options, the cocoon offers a better balance between immersion and comfort. No wearable devices are required, making it more hygienic and easier to use in shared environments, while the combination of multiple senses promotes relaxation and distraction. The main downsides are that it requires physical installation and that the design is more complex compared to simpler solutions. However, these challenges are acceptable given the benefits the cocoon offers. Furthermore, the cocoon can be designed to be inclusive and accessible to all users, for example by making the seats removable and integrating a small ramp, allowing children in wheelchairs to easily enter and use the system.

To support the comparison, a decision matrix was created using key evaluation criteria. Each solution was scored from 1 (low) to 5 (high). Table 1 provides the result.

Table 1: Comparative table of solutions

Solution	Immersion	Comfort	Hygiene	Practicality	Feasability	Total
VR Headset	5	2	2	2	3	14
AR Glasses	3	2	2	2	2	11
Projection	3	4	5	4	4	20
Cocoon	4	5	4	4	3	20

Although projection systems and the cocoon achieve similar total scores, projection-based solutions lack the ability to create a personal and protected environment. For children experiencing anxiety, a sense of safety and reduced external stimuli is essential.

The cocoon provides a semi-enclosed, multisensory environment that enhances both emotional comfort and immersion. By combining the advantages of projection systems with a protected spatial design, the cocoon addresses the key limitations of existing solutions.

Therefore, the multisensory cocoon is considered the most suitable solution for reducing anxiety in pediatric healthcare environments.

Summary

Provide here the conclusions of this chapter and make the bridge to the next chapter.

Based on the state-of-the-art analysis, it can be concluded that existing solutions such as Virtual Reality, Augmented Reality, and projection systems each offer specific advantages in reducing anxiety in healthcare environments. However, none of these solutions fully combine immersion, comfort, hygiene, and practicality.

The selected approach combines projection-based visualization techniques, multisensory stimulation, and a semi-enclosed spatial design to create a controlled and calming environment around the patient.

Key components of the system include a short-throw projector, integrated speakers, a scent diffuser, ambient lighting elements, and a supportive seating structure within an enclosed shell.

This solution was chosen because it provides an optimal balance between immersion, comfort, hygiene, and practicality. Unlike VR systems, it does not require wearable devices,making it more suitable for shared healthcare environments. Compared to projection-only systems, the enclosed structure enhances the sense of safety and reduces external stimuli, which is essential for reducing anxiety in children.

Therefore, the proposed concept is an evidence-based multisensory cocoon that combines the advantages of existing technologies while addressing their limitations.

The next chapter will focus on the project management approach, describing how the project was structured, planned, and executed throughout the development of the cocoon concept.

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