

Article

# Environmental art design from a biomechanical perspective: Exploration of the psychological and physiological effects of the integration of transparent materials and traditional cultural elements on residential spaces

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## CITATION

Yan A, Zhao Z, Wang J.  
Environmental art design from a  
biomechanical perspective:  
Exploration of the psychological and  
physiological effects of the  
integration of transparent materials  
and traditional cultural elements on  
residential spaces. *Molecular &  
Cellular Biomechanics*. 2025; 22(1):  
862. <https://doi.org/10.62617/mcb862>

## ARTICLE INFO

Received: 21 November 2024

Accepted: 5 December 2024

Available online: 15 January 2025

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**Abstract:** With the advancement of urbanization, environmental art design is becoming increasingly important in contemporary Chinese interior design, especially in the design of modern rural villas. The integration of traditional culture and art has become an important way to enhance the artistic value and cultural significance of residential spaces. This article explores the psychological and physiological effects of interior design that combines transparent materials with traditional art elements from a biological perspective on residents. Transparent materials are like delicate optical structures in the biological world. They not only give the space a sense of lightness and openness, but their interaction with light also has a profound impact on the human body. From a biomechanical perspective, just like the sensitive capture of light signals by the biological visual system, transparent materials of different colors and materials can adjust light and shadow, and then act on the human nervous system and psychological state. Bright light passing through transparent materials is like a strong stimulus perceived by organisms, which can stimulate vitality; soft light is like a soothing signal, which can bring a relaxing effect. In addition, the integration of traditional cultural elements enhances the spiritual satisfaction of residents by evoking cultural identity and emotional resonance. This paper also combines case studies, such as Hiroshima Optical Glass House and Türkiye Draman Villa, to analyze how transparent materials can achieve the balance of visual, emotional and biological effects in the modern living environment, providing a new perspective for improving the quality of life of residents. The research results indicate that the organic combination of transparent materials and traditional cultural elements can not only improve the biological experience of residential spaces, but also promote physical and mental health, enhance the emotional value and cultural depth of the space. By applying insights from biomechanics, designers can create environments that support human physiology, ultimately improving residents' quality of life. This interdisciplinary approach offers a novel perspective on how interior design can significantly influence well-being and cultural depth in modern living environments.

**Keywords:** biomechanics; environmental art and design; transparent materials; traditional culture; residential space; psychological and physiological effects

## 1. Introduction

With the acceleration of urbanization in China, traditional culture and art are gradually being reexamined and integrated into modern interior design, especially in the design of modern rural villas and residences, where the reproduction of traditional elements has become one of the design trends. Environmental art and design, as a comprehensive discipline covering visual, emotional, and cultural aspects, is

developing in a more profound direction. By combining transparent materials with traditional cultural elements, designers can not only enhance the artistic value of the space, but also influence the psychological and physiological health of residents at a biological level. Therefore, analyzing the role of environmental art design from a biological perspective, especially the application of transparent materials in space, can provide us with new perspectives for a deeper understanding of the impact of living spaces on human health [1–3].

The relationship between humans and their living environment profoundly affects our physiological, psychological, and emotional states. Research in environmental psychology has shown that factors such as light, color, and form in space directly affect the human nervous system, thereby affecting emotional regulation, stress management, and concentration. Biological research has also shown that natural light, color, and material texture play a significant role in influencing human physiological responses. For example, soft light can stimulate the human endocrine system, increase the secretion of melatonin, promote sleep and physical recovery; fresh colors can regulate the nervous system, help reduce anxiety, and enhance overall happiness. In addition, transparent materials in space create different light and shadow effects by refracting and reflecting light, which not only changes visual perception but also has a significant impact on the regulation of the human body's biological clock. Especially in modern cities, the reasonable application of transparent materials can help create a more comfortable living environment due to issues such as short sunshine hours and light pollution [4–6].

The importance of the application of transparent materials in biology is particularly reflected in their regulation of light and their impact on human physiology. Natural light is one of the key factors in maintaining the physiological rhythm of the human body. Through the clever use of transparent materials, the flow of light can be effectively guided and optimized, the indoor lighting intensity and color temperature can be adjusted, thereby improving the livability of the space. For example, natural light through transparent glass or acrylic sheets can simulate the soft light of morning and dusk, helping the human body's biological clock maintain stability in the modern pace of life and promoting a healthy schedule. The special properties of transparent materials not only make the space more transparent and open, but also create a good lighting environment, which is crucial for human emotional management and physical and mental health. The changes in light, along with the colors and materials in space, can trigger different emotional responses, such as warmth, tranquility, or vitality. These emotional changes are closely related to changes in the physiological state of the human body [7–9].

Biological research has also found that the use of transparent materials can not only optimize light, but also affect human physiological responses through the texture and touch of the material. Touch is an important way for humans to perceive the outside world, especially in interior design, where the texture, texture, and delicacy of materials directly affect the perception experience [10]. Transparent materials, such as glass, acrylic, etc., usually have smooth and cold surface features. This tactile sensation has a certain cooling effect on human physiological reactions and can effectively reduce physiological tension. On the contrary, materials with warmer textures such as wood and fabric can bring a comfortable and relaxing physiological

feeling. Therefore, the reasonable combination of transparent materials and other natural materials can effectively balance the temperature and tactile experience in the space, providing residents with more comfortable biological feedback [11,12].

In addition, the emotional effects of transparent materials are also very significant at the biological level. The core of emotional design lies in mobilizing people's emotional responses, and the stimulation of these emotional responses is often achieved through biological mechanisms. For example, the interaction between color changes and light can trigger different physiological responses, such as increased or decreased heart rate and blood pressure. These reactions can directly affect a person's emotions, which in turn can impact their mental health and physiological state. The combination of transparent materials and colors in design, especially in the interweaving of light and shadow effects, can create a highly emotional spatial atmosphere. For example, warm toned transparent glass or water wave textured acrylic panels, under the refraction of light, will create a warm and peaceful visual effect in the space, thereby stimulating a sense of relaxation among residents; cold toned transparent materials may create a fresh and calm atmosphere, which helps to stabilize and soothe emotions. By carefully designing these emotional details, transparent materials not only provide visual beauty, but also bring psychological comfort to residents.

In addition, the integration of traditional cultural elements is also a biological factor that cannot be ignored. The application of traditional culture in interior design is not only a return to aesthetics, but also a deep exploration of human emotions and spiritual needs. The symbolic meaning and emotional resonance contained in traditional culture can subtly influence people's physiological states and emotional responses. Biological research has shown that human identification with natural and cultural symbols can trigger deeper emotional resonance, which in turn affects psychological and physiological health. For example, traditional Chinese elements such as screens, wood carvings, ceramics, etc., which carry cultural values and artistic forms, can be reproduced through environmental art design. This not only brings visual enjoyment, but also enhances the cultural identity and sense of belonging of residents, thereby stimulating positive emotional reactions and benefiting physical and mental health.

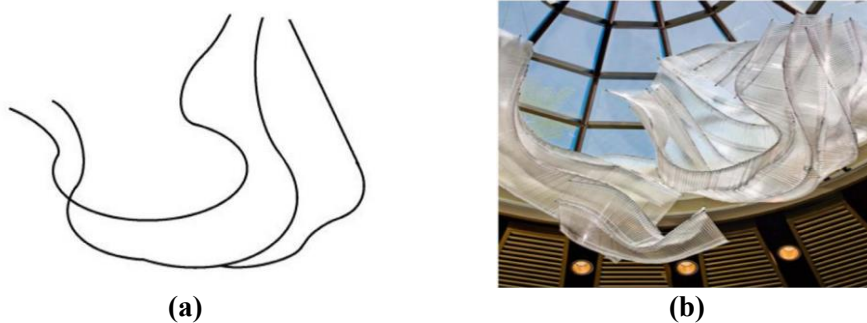
## **2. Materials that are transparent in the style application space**

### **2.1. Line element transformation**

The formal features of streamline art works include of multiple components, the primary ones being the sense of material, sense of form, and sense of form [12]. Various media materials, as well as texture, grain, and touch, all affect the perception of material. Different materials elicit distinct sensations, aesthetic values, and psychological and visual impacts. A form of art known as "material art" is created by artists that even employ the gloss, texture, color, and other visual qualities of specific media as the subject matter of their works. When it comes to fostering peace, soul, and nature, transparent materials have an incomparable aesthetic value [13].

The most appropriate material to hang lamps, lanterns, or decorative items from is transparent material because it can provide a feeling of purity and openness. When

thick wood, metal, or other opaque materials are used in an interior space above a certain height, the weight will feel heavy and may also induce anxiety and pressure in the mind [14,15]. The combination of transparent material and simple abstract lines can create unusual visual effects. The design techniques used include abstract curved line elements for restructuring and transformation, line with surface (**Figure 1a**), play with the material properties, so that the streamlined shape and the acrylic combination, to some extent, create a leap in the air that has a psychological effect of freedom, lightness, and spontaneity. The meandering flow of the lines gives the acrylic lightness of the leap sense of floating for the lighting modeling to create a visual experience (**Figure 1b**). The acrylic is given a feeling of lightness and jumps by the meandering lines, which create a floating visual experience for the lamps and lanterns modeling (**Figure 1b**). In keeping with the Chinese people's pursuit of pure simplicity and ethereal aesthetics, look up and look down like a calligraphy ink painting, a skimmer, hooks and dots whisking, or rapid Xu or soothing, light and airy, endless changes. This creates a unique visual effect that is used to express transcendent emotions.

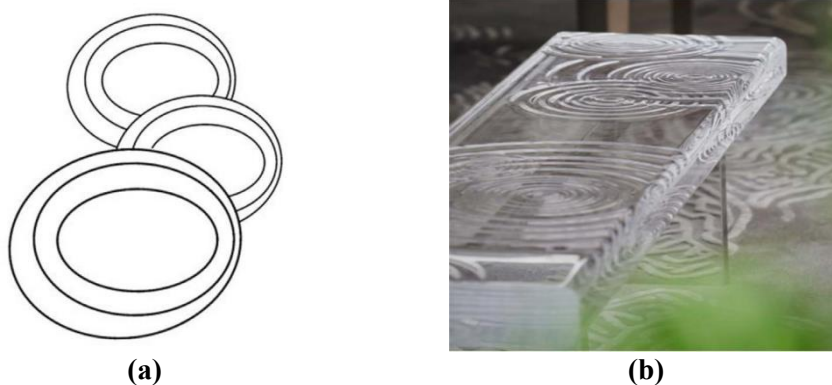


**Figure 1.** (a) Line elements; (b) lobby lights.

## 2.2. Attachment pattern

Though there are some points of convergence between traditional expressions of the mood of thinking and personalized and symbolic images, the modern home environment is more in line with the preferences of contemporary youth groups. Transparent materials can provide more artistic language to illustrate the beauty of the design, in which transparent home object furnishings play an irreplaceable role. In order to achieve the transmission of natural imagery in furniture design, designers frequently use visual image design methods to take elements from nature and turn them into simplified abstract patterns (e.g., **Figure 2a**). These patterns are then applied to the surface of transparent materials using welding, carving, spray painting, and other processing techniques. For instance, a straightforward table and stools can be sculpted from translucent materials like acrylic and other textured circles to depict the serene ripples of the imagery (**Figure 2b**). The Polymethyl methacrylate (PMMA) material's qualities allow it to have a high degree of brightness and glass light while also being more resilient and long-lasting. It is a good performance of the home space, not easy to damage the rupture of the texture is soft and feel no cold and prickly sensation, easy to maintain and clean. Sunlight entering the room through the glass window creates a hazy halo, a texture of acrylic water ripples, the lyrical realm of water in the area to be stayed in, modern materials and Chinese aesthetics in a location where collisions are

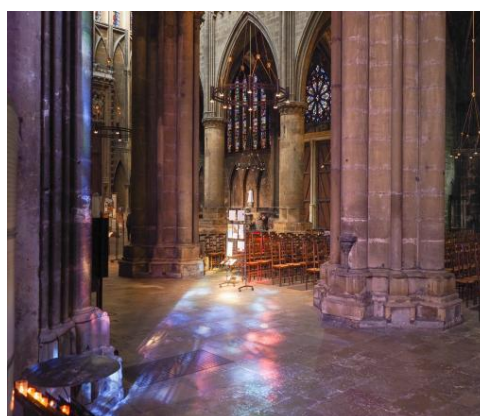
expertly blended.



**Figure 2.** (a) Patterned pattern; (b) watery.

### 2.3. Emotional design with color

Formal beauty is made up of bodies, blocks, surfaces, lines, and other geometric shapes. Another type of beauty is created when light is reflected off of glass. The use of glass in architectural interior spaces has always been closely related to light. Light can be projected onto the interior with psychedelic and enigmatic imagery (**Figure 3**), or it can be refracted through various colored stained glass panels, producing bright, clear, or hazy, soft light [16]. The focus of emotional design is primarily on the psychology of the user, which is defined as the division of user feelings into three layers: instinctive, behavioral, and reflective. These layers are the emotions produced by the human brain in reaction to external stimuli, and they include the reflexive level of brain cognition, the behavioral level of controlling daily activities, and the instinctive level of controlling pre-reflections. These three levels together constitute the fundamental emotional response of humans [17].



**Figure 3.** Shadow and light 1.

Different colors have different visual psychological effects on the human body. For example, blue represents mystery and stability and plays an effect of atmosphere creation in building a rational and peaceful space (**Figure 4**), yellow emotionally evokes a sense of hope and redemption, and green can relieve fatigue and relax the nerves. The emotional design of color is based on the application of materials, colors, soft furnishings, and other elements in the space with the instinctive level as the

starting point. For instance, green may calm anxiety and relieve weariness, blue symbolizes mystery and stability and helps to create an atmosphere in the construction of a logical and serene place (**Figure 4**). Yellow, on the other hand, emotionally invokes a sense of optimism and redemption. In the church and other places where it is necessary to create a mysterious and holy atmosphere of the interior space, different colors in the glass and other transparent materials under the intervention of light and shadow to give more expressive power, stimulate people in the space to produce emotional echoes of fluctuations, resulting in a mysterious and fantastical visual sensations and mind blowing.



**Figure 4.** Shadow and light 2.

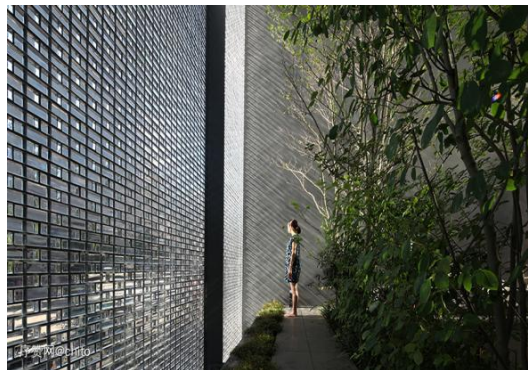
### **3. Transparent materials in an application case study for living spaces**

#### **Optical glass room in Hiroshima**

Exceptional progress has been achieved by designers worldwide in the use of transparent materials. The majority of Japan is heavily inspired by East Asian culture, and the design emphasizes interaction and dialogue with nature while pursuing and renewing the idea of harmonious cohabitation between architecture and environment. Most designers also strive for the idea of coexistence, which opposes segregation. A new generation of Japanese architects, Takashi Nakamura, excels in finding the connection between the natural and human environments through the use of translucent materials. In his creations, he attempts to subvert the notion of tradition in architecture and, via the use of novel materials, liberate the space. Emancipation of architectural walls: Traditional walls serve a utilitarian purpose but also disregard the importance of culture and communication. They are primarily used for load-bearing, enclosure, heat and sound insulation, and resistance to intrusion. Takashi Nakamura designs contemporary living spaces with the goal of using architecture to communicate with the surrounding environment. By using steel and transparent materials to reorganize and weigh different architectural elements, he breaks down the walls of buildings and allows the beauty of love and harmony to be seen throughout the living space.

The glass house in Hiroshima, Japan, is one of his most famous pieces. Double-layer structural bricks are used to form an 8.6-meter-tall wall of glass blocks that serves as the home's entrance. By dividing the interior architectural space with the glass block

wall's parallel vertical lines, the overall composition adheres to the plane concept. Despite being made of transparent glass, the double-layer brick structure and high-density arrangement give the area a visual shielding effect, maintaining the space's privacy while also creating an ethereal sense of concealment on the inside and outside, disrupting the isolated spatial combination pattern, and clearing the wall of clutter (see, for example, **Figure 5**). The two layers of light filtration on the exterior of the building guarantee that the light inside is soft. The green garden in the center of the house enhances the surrounding area while also allowing light filtered by the trees to pass through the glass wall to create the effect of heat insulation and shading. Light-transparent curtains with a metallic sheen sway in the breeze, and sunlight creates shadows and dappled light through the branches and leaves, creating a peaceful dream for the occupants. Finally, the tall glass wall appears as a cascade of light when viewed from the busy street (**Figure 6**). The tall glass wall appears to be flowing down a waterfall when viewed from the busy street (**Figure 6**). The glass brick wall serves as a good moisture-, heat-, and sound-proof barrier in addition to perfectly tying together the indoor and outdoor landscapes, which actually separates them. The entire area will be transparent and light-filled in the indoor living space to the greatest extent possible.



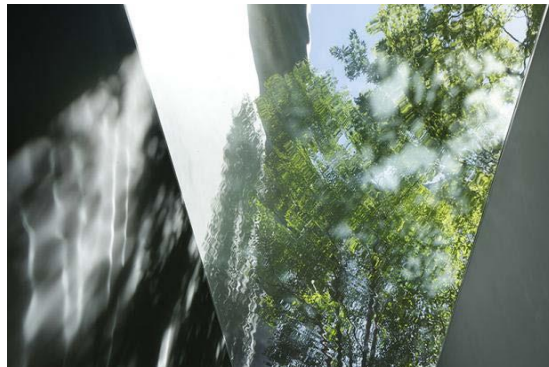
**Figure 5.** Glass wall.



**Figure 6.** Garden in the living room.

Top window: The upper part of the garden is exposed, and the pool's ceiling consists of a rectangular block of transparent glass that is horizontally covered. This mimics the external natural landscape by acting as a skylight while also serving as a water storage container, causing a circle of ripples to form whenever rain falls (**Figure 7**). The combination of several visual elements, such as the water's dynamic waves, the sky's blue field and white clouds, and the green trees, creates the illusion that the

sky and water are connected (**Figure 8**), perfectly echoing the idea of a divided yet unifying area. The visual impact of the connection between the water and the sky is achieved by combining dynamic water waves, blue fields, white clouds, and green trees from the bottom to the top. This precisely mirrors the spatial theme of separate but not apart (**Figure 8**). The designer attempted to create a tranquil, paradise-like land out of the middle of a busy city by using transparent materials that symbolize the modern world. The cold, modern building decoration material was now given a temperature, and the contrast between the quiet, peaceful interior space and the bustle of the outside world, along with the passage of time, is the best example of humanization created by a skilled designer [18].



**Figure 7.** First pool ceiling.



**Figure 8.** Second pool ceiling.

Turkey's Dramatic Villa 1. Using the design method of connecting the real with the virtual, the designers of Draman Villa in Turkey skillfully integrate transparent elements with the natural landscape to create a living space in line with modern aesthetics. They view plants, the sky, and mountains as elements of interior design. The combination of various materials is used to divide the two functional areas of the kitchen and dining room, separate the activity lines, break the spatial boundaries, remove the feeling of visual oppression, and make the interior space transparent. The living room is composed of reinforced concrete walls with tempered glass (**Figure 9**). The long wooden dining table mimics the motif of nature, maximizing the sensation of openness and generosity. The rows of floor-to-ceiling glass windows on the side not only bring the outdoors inside, but they also balance out the heavy wooden furniture. Half of the glass curtain wall is spliced into the upper portion of the bedroom wall, utilizing a design technique that unifies the interior solid space with the exterior virtual



natural landscape, removing obstructions to sight and extending the space for visual significance (e.g., **Figure 10**). The finishing touch to the modern minimalist theme of the bedroom is the blending of material elements, which blurs the boundaries of the space and gives the impression that you are floating over rivers and mountains. The modern glass and glass that makes up the entire villa. Modern glass and natural wood, two seemingly unrelated materials, are combined throughout the villa to produce a multifaceted and harmonious beauty.



**Figure 9.** Living area.



**Figure 10.** Bedrooms.

Usage of material combinations: a public transition area with furnishings made of marble, wood, and acrylic; a corner aisle with acrylic desktop and wood wall panel drawers; a quiet glass vase with a simple form; the coexistence of hard and soft furnishings in a harmonious, natural, stable, and pure manner; the natural beauty of the mix with a sense of science and technology (**Figure 11**). A big section of high transparent glass sliding doors in the living room open up the space, let in natural light, let in views of the surrounding mountains and river, reflect the solid furniture, and create an airy and light interior (**Figure 12**). The translucent material's texture and the designer's matching design work together to create a modern living area that is both aesthetically pleasing and psychologically stimulating.



**Figure 11.** Corners.



**Figure 12.** Living room.

#### **4. Situation of villas**

(1) The Suzhou traditional garden's spatial arrangement of many entry courtyards is used; an outdoor corridor separates and connects the courtyards for various purposes. As illustrated in **Figure 13**, the garden takes the multi-entry courtyard's residential texture and blends it with modern people's concept of living to create a living space that meets their needs and redefines the garden-style residence in a way that is contemporary. (2) The fusion of modernism and tradition. In order to create a vibrant and lively courtyard space, the public landscape is integrated into the private courtyard of the mountains and petrochemical wood, achieving a "step by step" visual effect. The combination of traditional architecture and modern technology includes the use of modern insulation and waterproofing technology. Gardening techniques, including the use of "hidden, hidden, leakage, penetration" and other traditional gardening techniques, are combined with modern design techniques. the utilization of contemporary waterproof and heat-preservation technologies combined with historic architectural design. (3) The peaceful dialogue between humans and nature is reflected in the combination of humanistic and naturalistic landscapes.



**Figure 13.** A family garden combining traditional and modern gardening methods.

## 5. Discussion

In recent years, the field of environmental art design has witnessed a remarkable evolution, especially when examined from a biomechanical perspective. The integration of transparent materials and traditional cultural elements in residential spaces has emerged as a fascinating area of exploration, with profound implications for the psychological and physiological well-being of inhabitants.

Transparent materials, such as glass and acrylic, offer a unique aesthetic and functional value. From a biomechanical viewpoint, they enhance the flow of natural light, which is crucial for regulating our circadian rhythms. Exposure to ample daylight helps in the secretion of hormones like melatonin, promoting better sleep patterns and overall physiological health [19,20]. In a residential space, a glass-enclosed living room, for instance, can flood the interior with sunlight during the day, creating a warm and inviting atmosphere. This not only reduces the need for artificial lighting but also connects the occupants with the external environment, providing a sense of openness and freedom [21]. When combined with traditional cultural elements, the design takes on a deeper meaning. Traditional motifs, colors, and patterns can evoke a sense of cultural identity and belonging. For example, incorporating Chinese lattice patterns in transparent partitions or window designs can add an elegant and historical touch. Psychologically, this connection to heritage can instill a sense of pride and comfort, grounding individuals in their roots. It creates a space that is not just a physical shelter but a repository of memories and values.

Moreover, the interplay between transparency and tradition can influence social interactions within the home. A semi-transparent screen with traditional embroidery in a shared living area can offer a degree of privacy while still allowing visual connectivity. This encourages communication among family members, as they can sense each other's presence without feeling overly exposed. Biomechanically, positive social interactions have been linked to reduced stress levels, with the release of oxytocin promoting feelings of relaxation and trust [22,23]. However, challenges exist in this integration. Striking the right balance between modern transparency and traditional ornateness is crucial. Overuse of transparent materials might lead to issues like excessive heat gain in summers or a lack of privacy. Similarly, an overemphasis on traditional elements could make the space feel dated. Designers must, therefore, employ a holistic approach, considering factors like local climate, the lifestyle of the residents, and the overall architectural context.

In conclusion, the fusion of transparent materials and traditional cultural elements in residential design, when analyzed through a biomechanical lens, holds immense

potential. It can transform living spaces into havens that nurture both the body and the psyche, fostering a harmonious coexistence of modernity and tradition. By carefully navigating the design choices, we can create homes that are not only visually stunning but also conducive to a healthy and fulfilling life.

## **6. Conclusion**

In environmental art design, the use of transparent materials not only has aesthetic and cultural value, but also demonstrates its important role in biology. By carefully designing elements such as lighting, color, and material texture in the space, transparent materials can optimize the introduction of natural light and changes in light and shadow, thereby having a positive impact on human physiology. For example, proper lighting regulation can help maintain the body's biological clock, promote healthy sleep patterns and circadian rhythms, and ultimately enhance the overall health level of residents. Transparent materials can bring higher transparency and lighting comfort to spaces through interaction with natural light, which has a significant effect on regulating emotions, reducing stress and anxiety, and improving mental health.

From the perspective of tactile and visual feedback, the coolness and smooth surface of transparent materials can provide unique biological effects, help reduce physiological tension, and create a warm and comfortable spatial atmosphere through the combination with other natural materials, further regulating human physiological responses. The use of transparent materials is not limited to their aesthetic value in appearance. It is closely related to the biological reactions of the human body and can regulate the emotions and psychological states of residents through the overall design of the space.

In addition, the integration of traditional cultural elements makes environmental art design not only an innovation in visual space, but also a response to human emotional needs and physiological feedback. Biological research has shown that the role of cultural symbols and emotional resonance can stimulate positive physiological responses, thereby promoting physical and mental health at the biological level. By combining transparent materials with traditional cultural elements, designers can create healthy spaces that better meet the needs of the human body while providing aesthetic and cultural values.

**Author contributions:** Conceptualization, AY and JW; methodology, AY; software, JW; validation, AY, JW and ZZ; formal analysis, JW; investigation, JW; resources, JW; data curation, AY; writing—original draft preparation, AY; writing—review and editing, ZZ; visualization, ZZ; supervision, AY; project administration, ZZ; funding acquisition, JW. All authors have read and agreed to the published version of the manuscript.

**Ethical approval:** Not applicable.

**Conflict of interest:** The authors declare no conflict of interest.

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