THERAPEUTIC ARCHITECTURE DESIGN INDEX

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Abstract

The building industry as a whole is undergoing an evolution in sustainability. Within healthcare facilities there has been a particular focus on energy efficiency, indoor air quality, and improving delivery of patients' health care. There are ample opportunities for architects and designers to create conditions that productively bond natural and human systems to fulfill the social, economic, and health needs for future generations.

A Design Index for Therapeutic Architecture integrates the opportunity for architects to mitigate environmental concerns and therapeutic technologies to achieve a healthier human environment. This paper outlines the development of a design aid matrix that integrates built and human-health environments, as well as building and human performance.

Keywords: energy efficiency, evolution in sustainability, patient health care, therapeutic technologies, design aid matrix, built environment, human-health environment, building performance, and human performance.

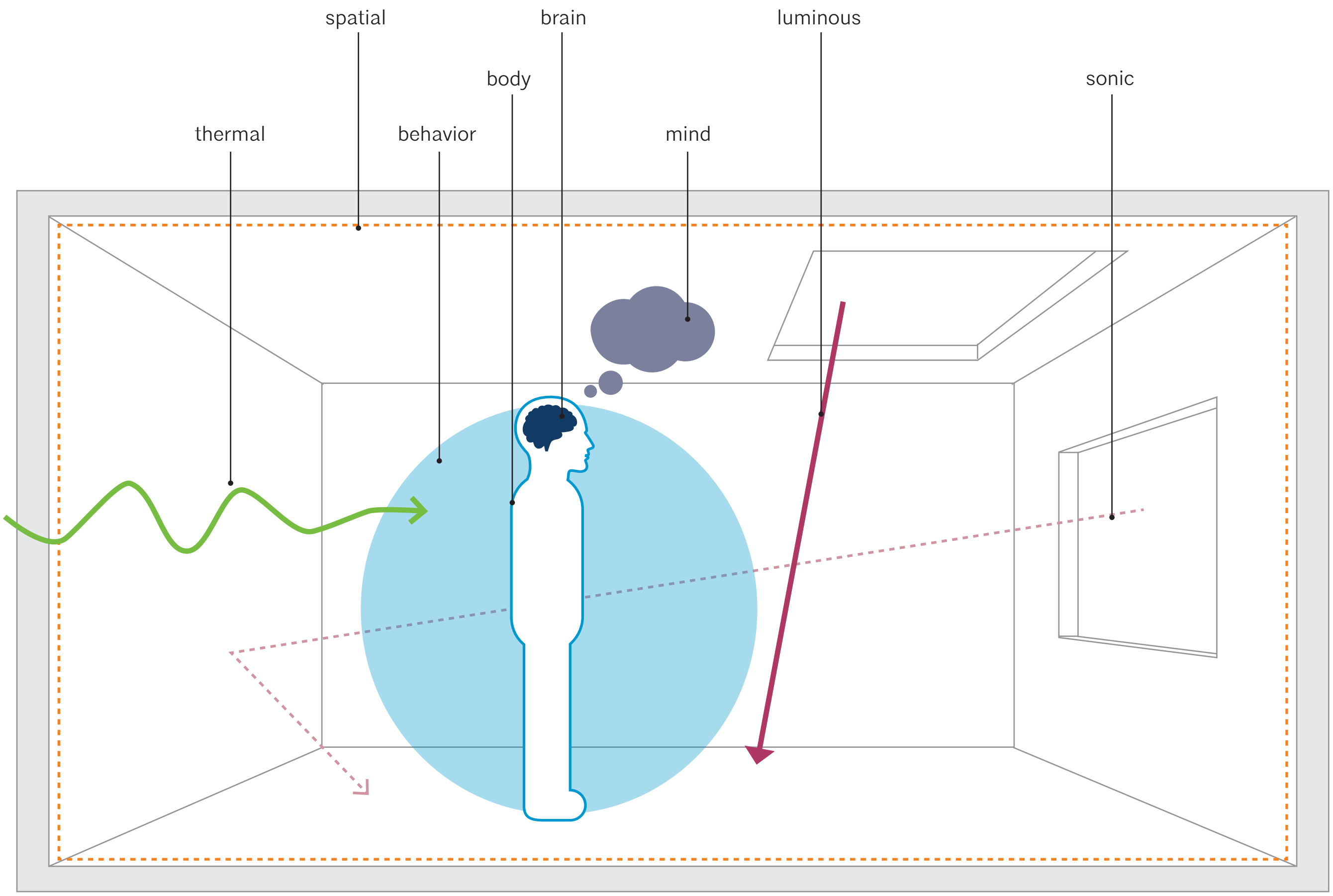


FIGURE 1. Analyzing the human environment within the built environment

Introduction

Humans' perception of the built environment is based on our ability to interpret adjacent environmental forces affecting bodily senses. Through our senses we form an image, and associate a memory with that image. As such, memories underlie much of our rich life; humans commonly associate dampness with smell, perceive dimension through echoes, and see light with shadow. Knowledge stored in our memory affects our behavior by way of predictions. Often, our perception of the environment relies as much on the knowledge stored in our memories as it does on fresh, incoming sensory information.

The built environments that we encounter affect our behavior. Perception stimulates the brain, accessing these images and memories. Architects and designers should not only be aware of how the built environment affects our behavior, but should also strategically design living spaces that consider this relationship.

Human health is essential for human performance. Architects should strive to create spaces that properly drive performance through a strategic and structured utilization of the built environment that stresses rigorous analysis of social, physiological, and psychological impacts. It is important to understand the role that spaces have on people and their emotions.

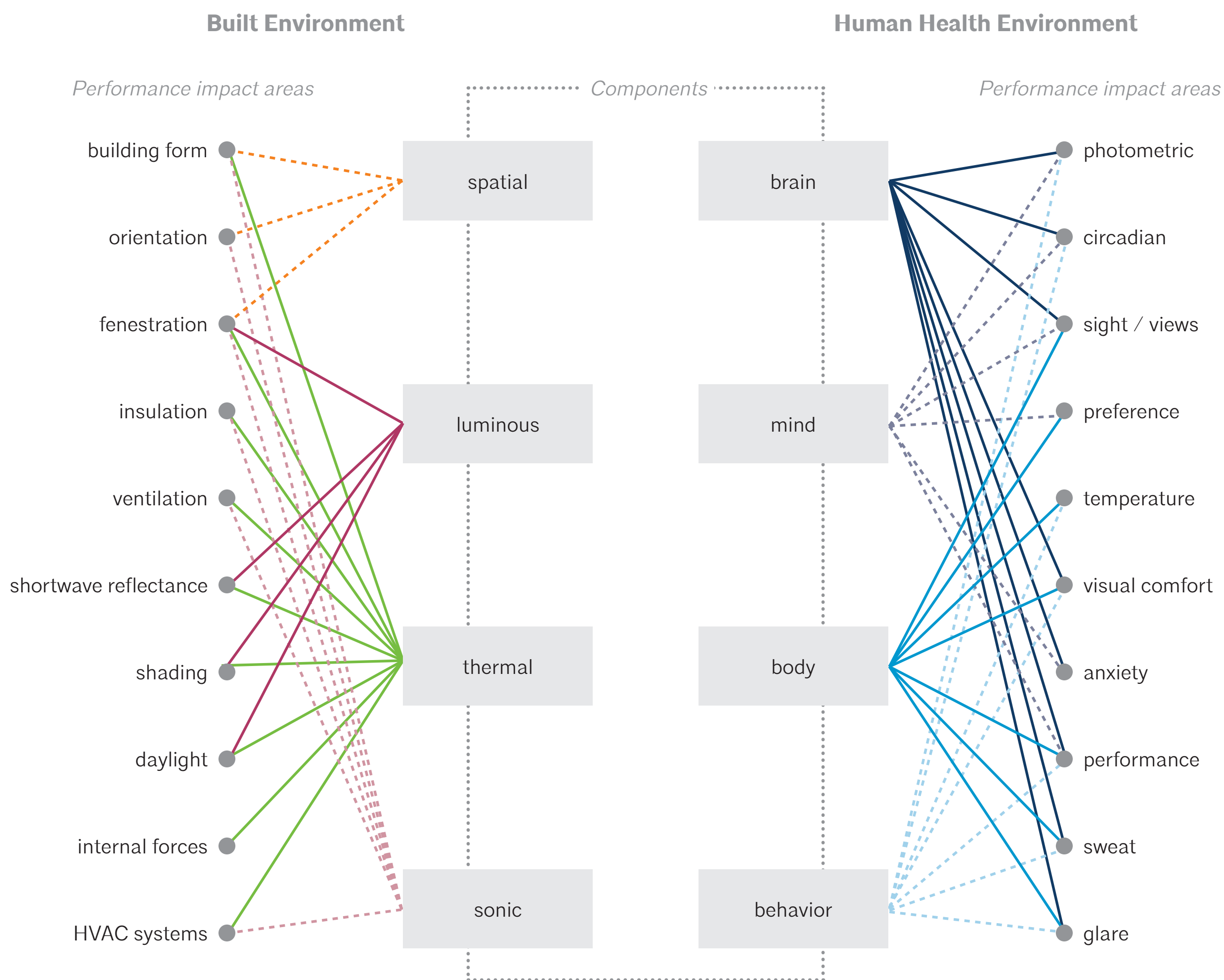
Architecture and neuroscience are no longer two discrete disciplines. Exploring the benefits of collaboration between neuroscience and perception, and architecture and the brain will yield a new dimension for design benchmarks, as human brains are continuously remolded by environmental forces and experiences. This collaboration does not only look at reducing patient stays, but also looks at providing a healthier, more productive way of living that may reduce people's need to go to a hospital in the first place.

We need to shift our minds from preventing health problems to causing health enhancements. Combining spatial design with health parameters, architects are able to make decisions and take actions that protect the natural world and preserve the environment to support future life. Further integrating environmental sustainability with therapeutic technologies achieves healthier human environments. This research project has established a design index to be used as a benchmark that supports and facilitates architects' integration of the built and human-health environments.

The visualization to the left illustrates the inception of how the idea of Therapeutic Architecture came about (Figure 1). Components of both the built environment and the human-health environment illustrate spatial, luminous, thermal, and sonic design with respect to the human brain, mind, body, and behavior.

Creating a design index for designers and architects to refer to ensures not only a healthier natural environment, but also a healthier human environment. The proposed relationship (Figure 2) will be studied from the experience of the experiments that have been discussed. In the context of this paper, special attention is paid to luminous intensities.

FIGURE 2. Design aid matrix connects performance impact areas through components of the built and human health environments



Building Performance

Energy efficiency is one of the most cost effective ways to enhance the environment. Humans are affected by energy through climate change and scarcity of resources. Humans are also directly affected by energy efficiency. As spaces are more efficient, humans could be provided with improved indoor air quality. Reduced heat loads lessen a building's reliance on HVAC systems for ventilation. Dr. Chalfoun has established ten built environment impact areas that have been considered and used in the development of this design index.

LUMINOUS INTENSITIES

Luminous intensities can be appreciated in many ways. They can be either more or less agreeable, more or less attractive, or they could be more or less appropriate to the function of the space. Variations of luminance and colors can strengthen attractiveness, trigger emotions, and affect our mood.

The impact of lighting influences individuals and their state of mind. A lighting installation that does not meet the user's sensory expectations can be considered unacceptable even if it provides for adequate visual performance. Unacceptable lighting conditions may impact human performance, motivation, and productivity.

Lighting should be designed to provide building occupants with the right visual conditions to help them perform visual tasks efficiently, safely, and comfortably. The luminous environment acts through a chain of mechanisms on human physiological, psychological, and sociological factors, which further influence human performance and productivity.

DAYLIGHT

Through history, daylight has been the primary source of light in buildings. Natural light improves livability, adds visual excitement, and reduces electricity consumption. Virtually all buildings in all climates can benefit from correct daylight design. Done correctly, daylight design reduces a building's internal heat load compared to that due to artificial electric light.

People perceive the luminous environment through their eyes and process it with their brain. Light scenes are therefore evaluated in connection to expectations.

ENERGY CONSUMPTION

The U.S. consumes almost 80% of electricity in building operation and is the largest emitter of greenhouse gases. The building sector affects many other industries, ultimately affecting the whole entire economy. When the building sector fails, the whole economy is adversely affected. Building operations alone account for 40% of all energy consumed in the U.S.; lighting is the largest contributor to energy consumption. Building construction and materials only count for 6% of energy consumed in the U.S.

The human body is the most receptive to environmental parameters, which include the luminous environment. The following section will describe how natural daylight could be used effectively and how it affects building occupants.

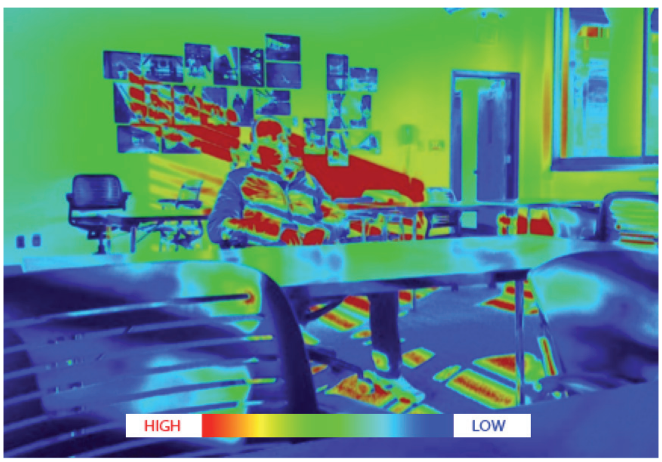
Human Performance

Human performance has become as important to architects as building performance. The built environment plays a major role in human productivity in the workplace and in happiness at home. Indeed, human performance is influenced and changeable by the environment. Human performance, body impact areas, and human thermal comfort were studied thoroughly in development of this design index.

Human performance is results-driven and focused on achievements valued by individual performers and their respective organizations as a whole. The approach taken here emphasizes the need to determine, assess, and evaluate root causes.

Validation and Application

FIGURE 3. Sunlight penetration causing visual discomfort



In this project, two studies have been conducted to validate the effects of natural daylight on human body performance: 1) photometric study, and 2) glare study.

Photometric Study

A photometric study has been conducted within Dinsmore Room, a conference room at the University of Arizona usually occupied for meetings events, and classes. This experiment primarily focused on the west façade of the room. The façade layers are comprised of a glass façade, interior textile screen, and aluminum framing with screen mesh. Owing to these retrofits to the façade, high performance is expected. However, when the room is viewed from a light intensity standpoint, disappointing performance is revealed (Figure 3).

Figure 4 illustrates how uncomfortable the seating in the room would be, especially during the later afternoon hours. A test was done with one of the author's colleagues sitting inside the classroom and looking straight at the board.

RECOMMENDATION Building codes require testing of illumination at 30" above the ground to indicate the level of light intensity on a work plane. However, occupants' visual comfort must have a different benchmark than this benchmark for buildings. Occupants of the room spend most of the time looking straight ahead, with the light from adjacent unprotected and un-shaded windows shining into their eyes.

FIGURE 4. Subjective depth of field

Glare Study

Perception of glare is caused by the fact that the occupied space has too much light intensity or a portion of the space has high intensity compared to an adjacent space with low-light intensity. Accordingly, the author has conducted a two-stage experiment to measure glare:

STAGE 1 As an observational method, the image in Figure 4 shows the human perception (subjective) compared to the measured (objective) depth of field. The intelligent human eye can naturally adjust to the various light intensity conditions whereas a camera cannot. The first condition (left) focuses on the foreground. The subject of the image is vaguely visible because the light intensity is very high (i.e., there is too much light). The second condition (middle) has a partial focus on the subject and on the background. It is considered to be the best of all three conditions. The final image (right) focuses on the background. The subject of the image is not clearly visible.

STAGE 2 A physical model was used to investigate light movement and render calculated through a space. This exercise is both a qualitative and quantitative study of day lighting conditions.

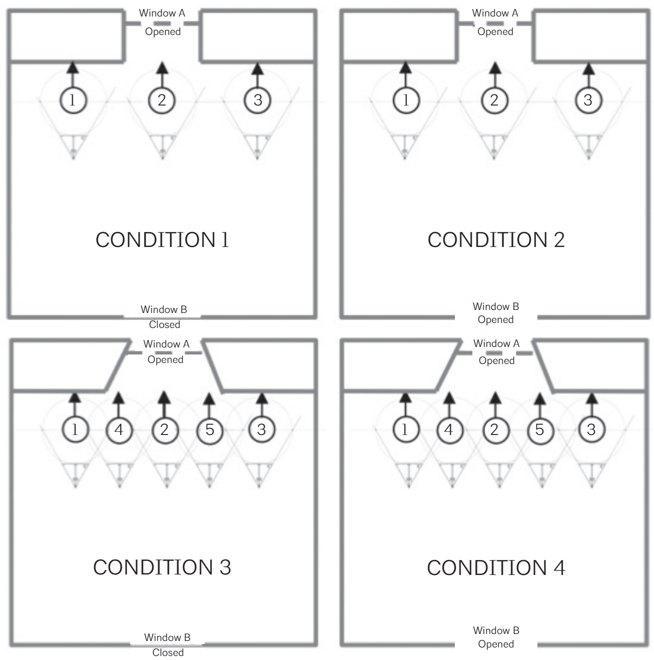
This investigation will cover the following points:

1) Construction of a simple square, 1"=1'0" daylight scale model that represents the space that will be tested. The model will be used to explore daylight variations within the space. The base of the model will be 20"x20", with a height of 10". All surfaces will be white to ensure even light reflectivity within the space. The study model will be sealed with duct tape on all corners to ensure that light will access only through the window being tested, therefore ensuring an accurate test.

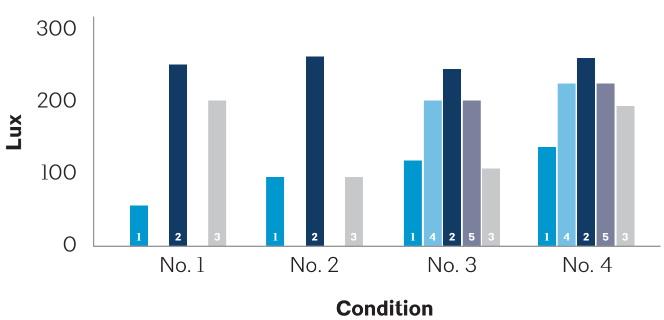
2) Using the House Energy Doctor's "Artificial Sky Simulator," the assessment of light distribution patterns was analyzed through photometric measurement of the model interior. There are two switches used to simulate conditions. One switch is used to test for over-cast sky conditions at about 17,000 lux while operating the "Mirror-Box" with both switches allows testing for clear sky conditions at about 22,000 lux.

3) Test model in four conditions. Two conditions will be tested on a regular window with two sources of lighting. The other two conditions will test two sources of lighting again, but with a transitional zone adjacent to the window.

FIGURE 5. Sensor placement and results



Light sensor readings



The next part will focus on the architectural solution to promote light intensity and distribution inside the space.

Condition 1: Window A Opened & Window B Closed, testing in one source of lighting within the space.

Condition 2: Window A Opened & Window B Opened, testing in two sources of lighting within the space.

For the two conditions described below, sensors have been added at the transitional zone at the window. After monitoring the readings of Test 1 in Conditions 1 & 2, an observation was made and the transitional zone was added.

Condition 3: Window A Opened & Window B Closed, testing in one source of lighting within the space.

Condition 4: Window A Opened & Window B Opened, testing in two sources of lighting within the space.

Figure 5 exposes the difference in delta intensity between Sensor 1 & 3 in comparison to Sensor 2, unlike the smaller delta intensity between Sensor 4 and Sensor 2 for Condition 4. Condition 4 is the best of all tests conducted; however, it is not the optimum condition for the actual space.

Some recommendations could be concluded from this test and should be included in both the design process and in the thought process of the architect or designer. Transitional zones decrease the chance for glare to occur as there is a decrease in the sudden drop of depths. The sudden drop initiates a high contrast that results in glare.

RECOMMENDATIONS

1) Design spaces with multiple sources of lighting.
2) Create transition zones for spaces or within a space.
3) Do not rely solely on the objective index of quantity of light, but also consider the subjective human visual comfort.
4) Creation of transition zones is advantageous for both window and space designs.

Conclusion

This research demonstrates the importance of integrating the built environment—represented by architecture—with the human-health environment. Ten building performance impact areas have been identified as have ten human performance impact areas. Collectively, these are there areas where the greatest potential for integration occurs.

To demonstrate one successful integration two experiments have been conducted to 1) test the photometric light intensity of a space, and 2) test glare conditions. Results of the two experiments focused on creating transitional spaces where the human eye can adapt to changes in light conditions. Space designers should create a balance between them.

It is also concluded that architects and building officials should begin to develop new performance indices that address more human performance rather than space performance. This became evident when the light intensity—although compliant with ASHRAE building standards—was found to be very poor to human perception as measured vertically. Fulfillment of building codes and standards does not necessarily achieve human visual comfort and sometimes may have an advert effect.

Future research can support the development of all of the integration required between the built and human-health environments. To address human health, we must verify that building codes are applicable to human comfort and efficient body performance, and we must amend those that are not.

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