New Design Ideas
Vol.4, No.2, 2020, pp.112-118

BIOPHILIA AND HUMAN HEALTH

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Abstract. The relationship of our environment to human health is receiving increased interest in the midst of a pandemic that has enforced radical behavioral changes around the globe. Recent scientific examination of the impact of natural views, settings, sounds and shapes reveals that our central nervous systems consistently respond positively to nature. By incorporating biophilic elements and features in the earliest stages of the project planning process, we can contribute to the creation of a healthy built environment.

Keywords: *biophilia, biophilic design, architectural programming, project phasing, health impact, wellbeing, salutogenesis, healing environments.*

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Received: *18 May 2020;* ***Accepted:*** *15 December 2020;* ***Published:*** *30 December 2020.*

1. Our Sense of Self

The human organism has evolved in relationship to an environment composed of natural systems expressed in fractal patterns and spatial complexity. Of course this is true of all organisms. What differentiates homo sapiens is, on the one hand, our highly evolved neural circuitry, and, on the other hand, our extensive modification of our environment. Human culture promotes a sense of our dominance over the natural world, celebrating human accomplishments while overlooking the natural systems that sustain all life, including our own. A large brain and technological proficiency promote an alienation from our instinctual roots, allowing for a certain hubris that tends to dismiss the externalities of our cultural "progress".

With the insights of ecology our understanding of the interconnection, indeed inseparability, of an organism and its natural environment, has begun to alter our sense of our selves. Simultaneously we have become increasingly aware of the negative impacts that civilization has imposed on the natural world. In the context of the struggle to address our excesses and find a new way of being in the world scientists and designers are looking more closely at the impacts of our built environment on our health and well-being. What they are finding could prove essential to restoring balance in our relationship to nature, facilitating progress towards a sustainable future.

2. Evaluating Impacts

In the early years of modern psychology Carl Jung pioneered the word association test, noting timing and emotional content as well as verbal responses. Jung was interested in the apparent spontaneity of responses, and experimented as well with monitoring heart

rate, blood pressure and galvanic skin response (GSR). This experimental approach revealed underlying "complexes" related to trauma and/or family patterns, and facilitated the process of psychotherapy by promoting the integration of unconscious contents. The physiological responses monitored, being involuntary, originated in the autonomic nervous systems of his subjects, and were typically associated with emotional content.

In evaluating responses to environmental stimuli researchers still monitor heart rate, blood pressure, and galvanic skin response, although newer technologies have expanded their repertoire. Most significantly, electroencephalography (EEG) and eye-tracking have provided insight into the autonomous responses of the central nervous system. EEG measures electrical brain activity and is a fundamental tool in psychophysiological research and cognitive neuroscience. Eye-tracking measures visual responses to stimuli in terms of areas of focus and time spent looking at any given point.

While not a biometric device, Virtual Reality (VR) technology has expanded the scope of experimental evaluation of reactions to stimuli by providing an effective means for exposure to artificial environments. In conjunction with eye-tracking VR can measure attention to specific elements in simulated environments (Yin & Spengler, 2019), providing valuable information to designers. It has been found that physiological reactions do not significantly differ between virtual exposure and real exposure to the same environment (Yin *et al.*, 2018). Consequently the impact of a proposed design can be effectively evaluated prior to its construction.

3. Biophilia

Humans are wired to respond to living things. The Biophilic Hypothesis articulated by Edward O. Wilson and Stephen R. Kellert in 1993 states that "human beings' innate connection with nature is essential for their well-being". There is ample scientific evidence to support this claim. In a study of simulated office-space Yin *et al*. concluded that "physiological results indicated consistently that biophilic interventions had positive effects on reducing stress levels" and "positive effects on improving participants' creativity" (Yin *et al.*, 2019). In fact a 'meta-analysis' summarizing the health benefits of outdoor nature showed that increased green space exposure is widely associated with significant decreases in diastolic blood pressure and heart rate (Twohig-Bennett & Jones, 2018). Conversely, we also have ample evidence that urban environments impact people's neural social stress processing and are associated with higher rates of psychosis, anxiety disorders, and depression than rural environments.

The dynamic of biophilia has been succinctly described by the Terrapin Bright Green group as follows: "The millions of neural channels in our brain link to the human body's autonomic nervous system. This system consists of two elements: the sympathetic and the parasympathetic systems. The sympathetic system stimulates the human body when cognitive function is needed. The parasympathetic system serves to relax the body, and is used for internal processes such as digestion. When the body's natural balance of sympathetic and parasympathetic is achieved, the body is in the ideal state of homeostasis" (Terrapin, 2012). With this information, and the tools to evaluate the impacts of an environment virtually, a new dimension in design becomes available.

4. Biophilic Design

Significant investigation into what, exactly, constitutes biophilic design has already begun. These accounts depict and substantiate various aspects of biophilic design in order to better facilitate its inclusion within constructed environments. Fundamentals include: views to nature, natural ventilation and daylight, access to green plants and water features, and the use of natural materials and biomorphic forms for indoor elements (Yin & Spengler, 2019).

Study groups report that visual connection with nature and dynamic and diffuse light are the preferred, i.e., most effective, input opportunities (Yin *et al.*, 2019). Reproductions of natural scenes cannot provide the same biophilic impact as actual views, landscapes, plants and natural forms.

Further analysis of biophilic impact reveals that fractal patterns found in nature are directly responsible for positive stimulation of human neural activity and parasympathetic system mechanisms (Terrapin, 2012). Salingaros has observed that "our immune mechanism is reinforced and our stress level is reduced in biophilic environments (Salingaros, 2019). Rachel and Stephen Kaplan have advanced an "Attention Restoration Theory" (ART) that articulates the influence of nature on cognitive activity via a state they call "effortless attention" (Kaplan & Kaplan, 1989). This theory observes that nature promotes a state of "soft fascination" by drawing our interest while allowing simultaneous mental processes such as reflection and imagination. ART goes beyond the dynamics of attention to establish benefits for stress management and health promotion.

Understanding that there are direct and immediate physiological responses to specific stimuli, and that these stimuli can be intentionally introduced to facilitate specific desirable cognitive and physiological responses, is the essence of biophilic design. Terrapin Bright Green has proposed fourteen patterns of biophilic design which fall within the four broad areas described above. The identification of these specific patterns allows for the systematic employment of design interventions to facilitate aspects of the biophilic response. Whether attention, stress-relief, healing, or creativity are sought, the design of the built environment can facilitate these outcomes. And the more we are exposed to biophilic stimuli the more pronounced are the results. Salingaros (2019) has cited studies that concludes "there is a significant correlation between living near forests and healthy brain structure (Kuhn *et al.*, 2017) and improved mental health (Bratman *et al.*, 2019; Preuss *et al.*, 2019).

Among all the outstanding work within biophilic design, this paper will highlight two outstanding approaches: The Biophilic Healing Index (Salingaros, 2019) and 14 Patterns of Biophilic Design (Browning *et al.*, 2014). Articulating and framing principles for biophilic design, which these two sources achieve, gives clear pathways to approach, initiate and evaluate the occurrence, and thus the impact, of biophilic design.

Table 1. Patterns of Biophilic Design (Browning *et al*., 2014)

Nature in the Space	
Visual Connection with Nature	Presence of Water
Non-Visual Connection with Nature	Dynamic & Diffuse Light
Thermal & Airflow Variability	Connection with Natural Systems

Natural Analogues	
Biomorphic Forms & Patterns	Complexity & Order
Material Connection with Nature	

Nature of the Space	
Prospect	Mystery
Refuge	Risk/Peril

Table 2. Ten Components of the Biophilic Healing Index (Salingaros, 2019)

Sunlight	Color
Gravity	Fractals
Curves	Detail
Water	Life
Representations-of-nature	Organized-complexity

5. Project Planning

Armed with the knowledge that the design of our environments can result in decreased blood pressure, improved short term memory, decreased negative and increased positive emotions, lower systolic and diastolic blood pressure and skin conductance level (Yin *et al.*, 2018), reduced absenteeism, improved academic performance, increased physical activity, improved mental health and cognitive function, enhanced immune function, and increased parasympathetic and lowered sympathetic nerve activity (Yin & Spengler, 2019), the design professions are now able and ready to introduce biophilic principles into the built environment. This must be accomplished systematically by establishing desired outcomes at the earliest project planning stage.

An architectural program will establish the use and size of required spaces, the optimum relationship of such spaces to one another, and additional requirements from energy performance to branding. The biophilic aspects of a design can also be determined and described during the programming phase. A valuable tool for this exercise is the "Biophilic Interior Design Matrix" created by Stephen Kellert (Kellert, 2018), consisting of six element categories and 72 related specific attributes. The elements differ somewhat from Terrapin Bright Green's patterns, with some overlap, while the specific attributes offer multiple application opportunities. Listed below are several of these opportunities in the context of their applicable elements:

Table 3. Biophilic Interior Design Matrix

#1 Actual Natural Features
- Air
- Water
- Plants
- Natural Materials
- Views and Vistas

#2 Natural Shapes and Forms
- Shells and Spirals
- Curves and Arches
- Inside/Outside
- Fluid Forms
- Botanical Motifs

#3 Natural Patterns and Processes
- Sensory Richness
- Age, Change and the Patina of Time
- Area of Emphasis
- Patterned Wholes
- Patterned Spaces

#4 Color and Light
- Composition
- Communication
- Preference
- Engagement
- Pragmatics

#5 Place-based Relationships
- Geographic Connection to Place
- Historic Connection to Place
- Ecological Connection to Place
- Cultural Connection to Place
- Integration of Culture and Ecology

#6 Human-nature Relationships
- Prospect/Refuge
- Order/Complexity
- Curiosity/Enticement
- Mastery/Control
- Attraction/Attachment

The Living Building Challenge, the most rigorous and thorough of the sustainability rating systems, requires that the design team hold a one day exploration of potential biophilic features in the initial planning stage of a project in order to establish clear goals and strategies early in the design process. The inclusion of all team members in this process broadens the scope of input and creates buy-in from all disciplines.

Planning for Biophilia goes to the heart of the user experience and therefore to the value and effectiveness of the design. In our next section we will see how it also impacts the bottom line.

6. The Economics of Biophilia

In their working paper on "The Economics of Biophilia" Terrapin Bright Green points out that productivity costs (related primarily to employees) are 112 times greater than energy costs in the workplace. Terrapin's business plan is based on the readily understandable statement that "introducing certain elements of nature into commercial buildings results in increased productivity and employee satisfaction" (Browning *et al.*,

2014). However productivity is not the sole benefit of biophilia. Enhanced learning comprehension and test scores have been demonstrated in multiple educational environments. Biophilic elements also can enhance social fabric, strengthening a sense of community. However the proven efficacy of biophilia in increasing healing rates may hold the greatest economic benefit of this approach.

As stated in their 'Economics' report Terrapin Bright Green claims that "in the $2.5 trillion healthcare industry, simply increasing views from hospital beds to nature could yield over $93 million in annual savings nationwide as patients require less time in the hospital to recover from major surgery" (Terrapin, 2012). Elsewhere it has been noted that "mental disorders have become one of the largest factors in (the) global disease burden. Approximately one in five adults in the U.S. experiences mental illness, including anxiety and depression, which are often associated with, or triggered by, a high level of stress. Better understanding of interventions that ameliorate stress and anxiety are needed given their negative consequences for human health" (Yin *et al.*, 2020).

Along with the health benefits of biophilia the economic incentive to adopt its principles becomes considerable. In fact these benefits need not be limited to the workplace and the hospital, as all interior and exterior environments can benefit from their application.

7. Conclusion

Evidence-based design adopts the position that design decisions have predictable outcomes, and that such decisions should be based on the outcomes sought. With the scientific investigation of biophilia we have conclusive evidence of strategies capable of facilitating a range of desirable outcomes that can be used effectively in all conceivable environments. The early planning phases of a project provides an opportunity to establish the strategies and goals for a given project. Biometrics and VR technology provide the means for evaluating the effectiveness of these strategies. In a similar manner the commissioning phase can evaluate the effectiveness of the strategies as implemented. Insights regarding the relationship of neuroscience to endocrinology make it clear that the environments that we construct impact us in ways that could not previously be imagined.

The concept of biophilia bridges the gap between the unfolding explorations of neuroscience and the environmental crisis that threatens to disrupt civilization irrevocably. Salingaros has described the benefits of biophilia as follows: "since biophilia is an essential part of human biology, building according to its principles … satisfies part of what is required for sustainability, in two ways. (i) The built structures are conceived as extensions of our biology and our ecosystem; (ii) we feel healthier in them, and therefore we will feel more motivated to preserve them against wear and tear and replacement" (Salingaros, 2019). With an evolving sense of self that prioritizes natural patterns and systems as essential to well-being perhaps homeostasis can be restored, not only to our autonomic nervous systems, but also to the all-encompassing systems of our biosphere, on which all life depends.

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