

The Science Behind Happy Spaces

By Anna Tavis

If we spend 90 percent of our time indoors, and most of our waking time working, how do we become smart about creating spaces that make us happy, enhance productivity, reduce stress, and motivate us to collaborate and innovate for the longest possible time? This Perspectives column gathers some of the world's leading architects and designers armed with new science and offering compelling evidence-based design solutions to the workplace challenges of today.

In our lead Perspectives, Bill Browning of Terrapin Bright Green launches this important conversation with the provocative thesis, “Biophilia, Buildings, and Your Brain.” Browning cites emerging research in a variety of scientific fields to make the case for how our environment can deeply affect our well-being. Informed with the new science, Browning explains his 14 evidence-based principles of new biophilic design that make you “smarter at work.”

David Briefel, Gensler's sustainability director, offers a cautious but optimistic response. In Briefel's view, “a truly biophilic approach must be holistic.” He advises against the temptation designers may have to attribute the impact on health and productivity to a single factor in isolation from the workplace culture, management, personal preferences, and individual psychologies.

Ken Wilson, a principal and chief sustainability officer at Perkins+Will, points to a significant crossover between biophilic design and the current management focus on improved collaboration and productivity. Among signature design projects used as illustrations for Perkins+Will's biophilic approach is the American Society of Interior Design that is seeking both LEED-CI Platinum certification and also WELL Building Standard certification. The building is designed as a living laboratory with the elements of “prospect, refuge, mystery, and dynamic



Office interior of Art Aqua in Bietigheim, German.

Credit: Bill Browning

lighting,” among many others.

Chris Trott, of Foster + Partners, provides a “back into the future” perspective to the biophilia debate. As a firm, Foster + Partners have been on this journey for more than 50 years, but recently, a more quantifiable body of evidence of the value of biophilic design has been developed with the particular interest in well-being and health. We are reinventing the past with the future in mind.

Lance Hosey, a principle at Perkins Eastman, asks the provocative question, what if beauty is not at all in the eye of the beholder, but in the beholder's genes? He cites the evidence of “neuro-aesthetics” and “bio-aesthetics” to support the fact that our perceptions of beauty is biologically wired and transcends individual differences as well as race and gender. In conclusion, Hosey confirms that supported by science, it is possible to design spaces that universally improve human responses to our environment.

The implications of these scientific

discoveries and their adoption by the leaders in architecture and design are vast and impressive.

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POINT

Biophilia, Buildings, and Your Brain

By Bill Browning

Is your workplace making you dumb? Literally, is the space where you work impairing your cognitive abilities? What if the conditions in your building actually improved your cognitive function, reduced your stress, and enhanced your creativity? Emerging science indicates that it is possible to design spaces

that improve these responses. Recent studies in neuroscience, endocrinology, environmental psychology, and other related fields are revealing how the spaces where we work and live can deeply affect our health. Armed this new information, we can conscientiously design spaces that boost productivity and support well-being.

In a previous column for *People + Strategy* (“Healthier Workplaces, Happier Employees,” Vol. 38.3), we explored the basics of biophilic design, or built environments that connect people with experiences of nature. Positive experiences of nature elicit beneficial psychological and physiological responses, such as lowered blood pressure and heart rate, reduced muscular tension, better mental focus, lowered levels of stress hormones, and enhanced creative problem-solving abilities.

After examining and collating numerous scientific studies, Terrapin Bright Green has identified 14 design elements, or spatial patterns, that support these desired outcomes. The 14 patterns of biophilic design are not new inventions, but rather codification of the science behind why we respond to certain traditional design elements. It is evidence-based design, or in other words, a scientific understanding of why we like certain places better than others.

The 14 patterns of biophilic design are clustered into three sets of experiences: **Nature in the Space**, which refers to direct experiences of nature, **Natural Analogues**, which are representations of nature, and **Nature of the Space**, which replicate preferred spatial experiences found in natural settings.

Nature in the Space

1. Visual Connection to Nature
2. Non-Visual Connection to Nature
3. Non-Rhythmic Sensory Stimuli
4. Access to Thermal and Air Flow Variability
5. Presence of Water
6. Dynamic and Diffuse Light
7. Connection to Natural Systems

Natural Analogues

1. Biomorphic Forms and Patterns
2. Material Connection to Nature
3. Complexity and Order

Nature of the Space

1. Prospect
2. Refuge
3. Mystery
4. Risk/Peril

These patterns are meant to guide designers on how to create healthful, productive spaces. Effective biophilic spaces may display several of these patterns in tandem. The scientific evidence indicates that some of the 14 patterns support multiple outcomes, whereas other patterns are only linked with one outcome (see the chart below listing an overview of the health outcomes of each pattern). Because each pattern has

a specific health outcome, a designer for a workplace must carefully select patterns with the intended health outcomes appropriate for that space (for example, any patterns that lower stress, improve cognitive function, and improve mental focus would be appropriate for most workplaces). Below are some examples of use of the patterns for specific outcomes, and the science to support them.

Stress Reduction

A Visual Connection to Nature (pattern 1) can cause the brain to shift to a less stressful mode of processing. Attention

TABLE 1. BIOPHILIC DESIGN PATTERNS & BIOLOGICAL RESPONSES

Table 1 illustrates the functions of each of the 14 Patterns in supporting stress reduction, cognitive performance, emotion and mood enhancement and the human body. Patterns that are supported by more rigorous empirical data are marked with up to three asterisks (***) indicating that the quantity and quality of available peer-reviewed evidence is robust and the potential for impact is great, and no asterisk indicates that there is minimal research to support the biological relationship between health and design, but the anecdotal information is compelling and adequate for hypothesizing its potential impact and importance as a unique pattern.

14 PATTERNS	+	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
NATURE IN THE SPACE	Visual Connection with Nature	Lowered blood pressure and heart rate (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005)	Improved mental engagement/ attentiveness (Biederman & Vessel, 2006)	Positively impacted attitude and overall happiness (Barton & Pretty, 2010)
	Non-Visual Connection with Nature	Reduced systolic blood pressure and stress hormones (Park, Tsunetsugu, Kasotani et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsaga-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991)	Positively impacted on cognitive performance (Mehta, Zhu & Cheema, 2012; Ljungberg, Neely, & Lundström, 2004)	Perceived improvements in mental health and tranquility (Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Rhee, & Fielking, 2007; Stigsdottir & Grain, 2005)
	Non-Rhythmic Sensory Stimuli	Positively impacted on heart rate, systolic blood pressure and sympathetic nervous system activity (Li, 2009; Park et al., 2008; Kahn et al., 2008; Beauchemin, et al., 2003; Ulrich et al., 1991)	Observed and quantified behavioral measures of attention and exploration (Wirdhager et al., 2011)	
	Thermal & Airflow Variability	Positively impacted comfort, well-being and productivity (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005)	Positively impacted concentration (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989)	Improved perception of temporal and spatial pleasure (alliesthesia) (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979)
	Presence of Water	Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure (Alvarsson, Werni, & Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman & Vessel, 2006)	Improved concentration and memory restoration (Alvarsson et al., 2010; Biederman & Vessel, 2006) Enhanced perception and psychological responsiveness (Alvarsson et al., 2010; Hunter et al., 2010)	Observed preferences and positive emotional responses (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphries et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orsini, 1993; Russo & Mzwiringer, 2003; Ulrich, 1983)
	Dynamic & Diffuse Light	- Positively impacted circadian system functioning (Triguero, Bruns, Pilanck et al., 2011; Beckett & Roden, 2009) - Increased visual comfort (Elyezadi, 2012; Kim & Kim, 2007)		
NATURAL ANALOGUES	Connection with Natural Systems			Enhanced positive health responses; Shifted perception of environment (Kallert et al., 2008)
	Biomorphic Forms & Patterns			Observed view preference (Vessel, 2012; Joye, 2007)
	Material Connection with Nature		Decreased diastolic blood pressure (Tsunetsugu, Miyazaki & Sato, 2007) Improved creative performance (I. Ichniowski et al., 2012)	Improved comfort (Tsunetsugu, Miyazaki & Sato 2007)
NATURE OF THE SPACE	Complexity & Order	Positively impacted perceptual and physiological stress responses (Sainjaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)		Observed view preference (Sainjaros, 2012; Hegerhall, Laake, Taylor et al., 2008; Hegerhall, Puccella, & Taylor, 2004; Taylor, 2006)
	Prospect	Reduced stress (Grain & Stigsdottir, 2010)	Reduced boredom, irritation, fatigue (Clearwater & Coss, 1991)	Improved comfort and perceived safety (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000)
	Refuge		Improved concentration, attention and perception of safety (Grain & Stigsdottir, 2010; Wang & Taylor, 2006; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993)	
	Mystery			Induced strong pleasure response (Biederman, 2011; Sainjaros, Bencovoy, Lancher et al., 2011; Kemi, 2005; Blood & Zatorre, 2001)
	Risk/Peril			Resulted in strong dopamine or pleasure responses (Kohn et al., 2013; Wang & Isen, 2011; Zaid et al., 2008)

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Restoration Theory (ART) posits that when you are experiencing nature rather than navigating the built environment, the brain shifts to a different mode of processing. Some of the higher cortical functions take a break and you experience the world through a state of “soft fascination.” When you return to the task at hand, you are refreshed and better able to focus. The question for a number of years has been, how long does it take for the brain to shift into this more relaxed mode? A team at Melbourne University undertook an experiment utilizing an fMRI machine. Participants were given a stress-inducing task and then a recovery task. They viewed one of two scenes: an urban rooftop consisting of concrete, or the same rooftop rendered as a green roof with extensive plantings. The participants who viewed the concrete roof during the recovery task did not exhibit a shift in brain processing mode. The participants who viewed the green roof shifted brain mode within 40 seconds and performed better on the recovery task.¹

The Presence of Water (pattern 5)—in particular, the sound of water—can change the perception of noise in an office environment. The team at the Psycho-Acoustic Laboratory at the Fraunhofer Institute has experimented with a variety of sounds to find a way to reduce problems associated with noise and in an open office. The team investigated the effect of white noise, pink sound, music, active noise cancellation, nature sounds, and moving water to help lower stress levels in an open office.

The sounds of water were found to be the most effective in lowering the perceived noise level in an office, although the sound of water does not lower the actual noise level in a space but in fact increases it. However, the human brain will focus on the sound of water, and filter out other noises.² This is much like the way we filter out surrounding conversations when we are talking with a friend at a cocktail party.

Cognitive Function

A Visual Connection to Nature (pattern 1) can also enhance the cognitive development of school children. There is a known annual progression of cognitive development in children. A study of

more than 2,500 children in the Barcelona school system investigated whether the amount of green space (defined as tree canopy) at home, on the way to school, or in the schoolyard has an impact on cognitive development. The children in the study were tested multiple times over the course of a 13-month period. The amount of tree canopy at home or on the way to school had a

Conscientious and targeted implementation of the patterns in a workplace can achieve desirable health outcomes for employees, a minimal investment that results in high productivity savings.

negligible effect. However, independent of socioeconomic factors, the children in schools with more tree canopy on the schoolyards had significantly higher levels of cognitive development over the children with little or no trees in the schoolyard.³

Another recent study found that cognitive performance of workers in an office is negatively impacted by high levels of CO₂ in the air. The study was undertaken by the Harvard T. H. Chan School of Public Health, Syracuse University, and SUNY Upstate Medical University with the Syracuse Center of Excellence on Indoor Air Quality. The participants worked for several days in what looks like a normal office, but is actually a giant space for testing indoor air quality. The CO₂ level was set at 500 ppm, somewhat above outdoor average, 950 ppm, a typically recommended level for buildings, and 1,500 ppm.

As part of their time in the space, the participants undertook a series of psychological tests. As the CO₂ level increased, cognitive function was impaired. Humans evolved in an era when CO₂ levels were in the range of 180–200 ppm. Today the global average outdoor level of CO₂ is now over 380 ppm. Implementing the pattern of Thermal and

Airflow Variability typically results in increased airflows and air changes in a space, drastically lowering CO₂ levels for better performance. In a world of elevated CO₂, we need the air and airflows indoors to be more like the natural settings outside.⁴

Emotion, Mood, and Preference

The introduction of an element of Risk/Peril (pattern 14) into the built environment can surprisingly elicit a strong pleasure response in the brain. In this pattern, space designers create a brief experience of implied danger with a clear safety mechanism. For instance, a short expanse of glass floor with a view to spaces far below can be thrilling and trigger a strong dopamine response in the brain.⁵ The Risk/Peril pattern can create memorable experiences, but probably should be used sparingly.

Application

Biophilic design might seem fine for the office of wealthy tech companies, but is it relevant in a manufacturing setting? The answer for Clif Bar was yes. The maker of sports bars is building an industrial bakery in Twin Falls, Idaho. Clif Bar wanted a facility that reflects the company’s outdoor heritage and supports the health and wellbeing of their team. Skylights, plants, animals, water features, and natural materials are all part of the culture of their office spaces.

Sanitary and safety standards, however, will not allow any of these features inside an industrial bakery. So instead, the facility will use, images of Clif Bar staff and customers eating their products out in nature projected onto the high interior walls of the main production space. Simulated views of nature will lower blood pressure and heart rate, although not as much as a real view to nature.⁶ There will also be a limited number of windows with views to the surrounding landscape, although these will be less effective during the nighttime shifts when the view is not visible. And the common areas will have a number of biophilic design elements to help the manufacturing staff recharge during breaks.

Smarter, More Productive Workers through Workplace Design

The workplace experience is obviously determined by much more than the design. Management, programming and engagement are crucial for supporting employee productivity, health and wellbeing. One critic has said, that there is not enough evidence yet to claim that we have a genetic need to connect with nature, or that all of the response mechanisms are not fully understood.⁷ That assertion should be a call to continue research, rather than ignore what science is out there to demonstrate the benefits of connecting people with experience of nature. The use of biophilic design should be viewed as another set of human resources tools to support positive outcomes in the workplace.

Biophilic design, especially interventions like the ones suggested above, can support places that stimulate our brain and keep us engaged. Conscientious and targeted implementation of the patterns in a workplace can achieve desirable health outcomes for employees, a minimal investment that results in high productivity savings. By leveraging these scientific findings, we can create better workplaces for healthier, happier employees. Let's be smart about this.

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COUNTERPOINT

Biophilic Design: A Cautiously Optimistic Perspective

By David Briefel

After reading Bill Browning's article, I am left feeling a mix of optimism and caution.

As a designer devoted to making a positive impact on humans and the environment, my intuition tells me that designing our workplaces to better reflect patterns in nature will, as the sampling of research presented by Browning suggests, increase our health and productivity. A deeper, more personal hope is that biophilic design can be a regular reminder to those of us who spend the majority of our days indoors that we are innately connected to the natural environment.

To be successful, a truly biophilic approach must be holistic. As Browning acknowledges, the workplace experience is complex, determined

by much more than just the design. As a designer myself, I understand this, and when speaking to clients am hesitant to attribute the impact of a single design feature on the health of employees without also discussing the variable conditions associated with op-

Perhaps the greatest value biophilic design has today is as a means to communicate the values of a company for the purpose of employee attraction and retention.

erations, human engagement, personal preference, and individual psychologies.

Hesitancy aside, the science presented in Browning's article shows that we are getting closer to understanding the impact of particular elements in specific environments. As such, I believe the framework in the article will provide an invaluable means to aggregate the research and bear out those patterns most effective at improving health and productivity. While many forward thinking companies are deliberately integrating biophilic design into their projects, ultimately, we need more projects that test these principles and track the impact on workers in a variety of settings.

Gensler is currently working with online retailer to incorporate an extensive interior greenery plan as well as three vegetated terraces, among many other biophilic design elements, in their new Brooklyn headquarters, which they plan on moving into later this year. Both Google and engineering firm Glumac have been experimenting with a variety of biophilic design features in their offices. Perhaps the most important but least discussed outcome of biophilic design today for our clients is a communication of organizational values resulting in employee attraction and retention.

At the end of the day, good design can never be formulaic, but it should be evidence-based. We must continue to develop measurement criteria and

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