Daylighting and healing – an exploration of the cause and effect/biophilia

By Dr. Michael Phiri

In recent years significant advances have been made in our knowledge and understanding of the relationship between lighting and human health. Findings from lighting research on offices, hospitals and schools report:

- White light as low as 200 lux at the cornea suppresses melatonin production at night. Sleep initiation is controlled by the suprachiasmatic nucleus of the hypothalamus and endogenous melatonin, both of which are influenced by environmental light. Exposure to evening light may cause circadian phase delay and melatonin suppression before bedtime, resulting in circadian misalignment and sleep-onset insomnia (Obayashi et al. 2014).

- Identified a new photo-receptor in the eye and established the spectral sensitivity of the human circadian system, which are strongly involved in the circadian variations of rhythmic physiological systems (Cajochen et al. 2003, Duffy et al. 2005, Rea et al. 2010). Light acts in the intrinsically photosensitive retinal ganglion cells (ipRGC) through melatonin and its metabolites (Zeitzer et al. 2000).

- Investigated the application of light as a mechanism to increase performance (Chellappa et al. 2011, Smolders et al. 2012) and alertness (Viola et al. 2008), affect behaviour (Wessolowski et al. 2014, Vaaler et al. 2005) and improve sleep in older adults. Exposure to bright light causes cognitive and behavioural changes not only during the biological night (Lockley et al. 2006), but also during the day (Sahin & Figueiro 2013).

- Reported improvements in motor restlessness and agitation in response to increases in ambient light levels in several studies of light therapy in dementia samples (Lovell et al. 1995, Haffmans et al. 2001).

Blue light interventions have been found to be effective in treating depressive disorders, especially seasonal ones (Terman & Terman 2005) but can also positively affect cognitive (Lockley et al. 2006, Vandewalle et al. 2006, 2007a, b) and physical (Kantermann et al. 2012) functions in healthy individuals. Human performance can be affected by lighting via three routes, through the visual system, the circadian system, and the perceptual system (Boyce 2003). One hour of exposure to bright, white light in the morning not only advances sleep and wake-up parameters, but also affects cognitive performance and alertness (Corbett et al. 2012).

Why the design of the built environment to optimise daylight provision matters

Daylighting brings many benefits to all environments of better outcomes such as enhanced productivity as well as fostering wellness and ultimately yielding greater occupants’ satisfaction with their physical environment.

Strategies for selecting and specifying a window arrangement and management system for the highest utilisation of daylight are crucial to achieve the potential benefits from daylighting provision. These include motorisation, integration with other systems, user control and understanding of shading devices, and its benefits.

An overview of daylighting, covers many design concepts such as site, façade orientation, glazing overview, the role of fabric weave and colour, winter/summer solar path and angle of the sun, and the differences of manual, motorised, integrated, user-controlled, and automated shading systems. Of importance when considering shading systems are energy savings and life cycle costings.
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In the past, incorporating inspirations from nature into designing buildings were necessary, functional and beneficial for aesthetic reasons. Designs used high windows and ceilings, surrounded by decorative mouldings or motifs of plants, flowers, birds and animals, that allowed abundant daylight overlooking courtyard gardens, green areas and tree-lined streets.

How should the built environment be designed to optimise daylighting and biophilia or the products of biological evolution?


The biophilia (“love of life or living systems”) hypothesis suggests that there is an instinctive bond between human beings and other living systems. It is people’s natural love for life that helps sustain life.

Designers are gleaning new approaches to creating the built environment based on this instinctual passion for natural places. Examples of biophilic design strategies include the incorporation of water features, healing gardens, daylight, and views of nature, as well as the use of natural materials or biomorphic architectural forms and features.

Our reaction to natural daylight is also biophilic. Sunlight was our sole source of usable lighting for the majority of our evolutionary path. The human eye has adapted to operate most accurately and efficiently in outdoor conditions. Unsurprisingly, we therefore complain about the harshness of fluorescent and other lighting fixtures or glowing monitors and computer screens. Findings from scientific studies on daylight show that classrooms and workplaces flooded with daylight lead to more productive students and employees.

Biophilia is purposeful and conscious design with nature in mind, with the understanding of what a connection to nature can do to a person physiologically. Separate from other energy and resource-saving forms of green design (although these benefits are often a side-effect), biophilia is the study of how a connection to nature can improve our health and well being.

Between 1999 and 2003 the Heschong Mahone Group, a California-based consultancy focusing on energy-efficient building practices, conducted a series of studies where students were observed in day lit and artificially lit classrooms. Findings reported that abundant daylighting enhanced learning rates by 20-26%. However, because the Heschong Mahone model was used incorrectly, Boyce 2004 later demonstrated that there was no significant variance due to sunlight.

Research has shown that premature babies recover faster when exposed to natural light. Studies by the European Sleep Research Society and Blackwell’s Journal of Sleep Research revealed that newborns sleep better and more sound in natural light than in artificially lit rooms.

Elzeyadi (2011) study of 98 and 175 employees in 120 administrative offices of a Northwest University Campus, USA hypothesized that better lighting quality, view quality, and daylight availability will have a positive effect in reducing sick leave of employees in an office setting and will contribute to fewer building related health symptoms and complains by the occupants. Findings from the study reported that workers in offices with poor ratings of light quality and in offices with poorer views used significantly more sick leave. Taken together, the two variables explained 6.5% of the variation in sick leave use, which was statistically significant.
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This paper reports on a state-of-the-art study quantifying the health and human impacts of daylighting strategies and views quality from windows on employees’ health in offices. The study attempts to quantify an important yet not scientifically proven assumption concerning the biophilic relationship between views of nature and daylighting in the workplace and their impacts on sick leave of office workers. The specific hypothesis tested is; that employees with a view of nature will take fewer sick days, have fewer Sick Building Syndrome (SBS) symptoms than those with a view of urban structures, or with no views out at all.

A corollary hypothesis is whether daylight availability and dynamic lighting quality in offices could also play a role in reducing the number of sick leave hours and SBS symptoms related to poor circadian rhythms and hypersensitivity. This is an objective to answer and quantify a long debated hypothesis regarding the importance non-residential building occupants place on the need to be in contact with nature/the outdoors while working within a building. This paper reports on a three-phase long-term study.

Overall, some people believe that daylighting affects and improves behaviour. Hence the adage ‘walk on the sunny side of the street’ in order to capture the more positive outlook provided under sunny conditions.

What strategies can be used to address unwanted glare and heat gain, a consequence of daylight provision?

Windows, roof lights and other openings in a building can serve to provide natural light but can also create a host of problems such as excessive glare, heat build-up, high energy costs and complaints of discomfort from occupants. Appropriate strategies that can be used to block out natural light can help address unwanted glare and heat gain.

A combination of exterior and interior shading devices can be used to control and redirect daylight, while horizontal louvers can be integrated into a double-skin façade to block sunlight. Triple-pane, low-emission glazing can be utilised to filter out UV light and reduce heat gain.

How can recent developments in artificial lighting technologies be applied in evidence-based design?

Evidence from research shows that appropriate environmental lighting with characteristics similar to natural light can improve mood, alertness, and performance (Arsenault et al 2012). In this case micro-restorative effects of daylight may result in lowered blood pressure and increased oxygen saturation and a positive effect on circadian rhythms (as suggested by body temperature) and morning sleepiness. Daylight has been found to be a more effective form of environmental lighting than electric lighting in boosting alertness and cognitive performance (Münch et al. 2012, Bellia et al. 2013). When indoor electric environmental lighting is not appropriate for our body’s natural state, occupants will be trapped in ‘biological darkness’ (Stevens & Rea 2001) a situation, where indoor lighting is not adjusted for the human body’s biological needs, resulting in circadian disruption with serious consequences on health and performance.

The reason for the widespread use of the fluorescent fixture is that the lighting engineers wanted control - to get precisely the right number of foot-candles delivered to the work surface at any time of the day. However, recent developments such as LED lighting are replacing the fluorescent fixture as the key to improving lighting conditions. Furthermore, with the introduction of computers and controls we also have a new world of daylight management, where shading devices, heliostats and skylights that can be integrated with interior lighting systems to obtain the best and cheapest light possible. Computer simulation allows consideration of various scenarios to fine-tune designs and help address the challenges of changing user requirements.
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References


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