

Effects of light on internal body systems psychology essay



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This report will consider if there is sufficient evidence to link natural lighting provision to the mental health and general well being of building occupants. It also considers spectral content when artificial light is used. Not only will greater reliance on natural light reduce energy consumption, which is becoming increasingly important, but will favourably impact human health and performance.

For the purpose of the report the study of natural lighting data has been divided into headings of Wavelengths of Light, The Affects of Light on the Body, which have been conducted in various building settings. Each building setting includes the effect daylight has on the building occupants psychologically and physiologically.

This report also presents summary information from a critical review on day lighting in buildings. It is the goal of the report to compile a listing of the literature that is commonly cited for showing the impacts of day lighting in buildings, and to prove that there is sufficient evidence to link natural lighting provision to the mental health and general wellbeing of building occupants?

2 Background and focus of topic

Before the 1940s, daylight was the primary light source in buildings; artificial lights supplemented the natural light. In the short span of 20 years, electric lighting had transformed the workplace by meeting most or all of the occupants' lighting requirements. Recently, energy and environmental concerns have made day lighting a rediscovered aspect of building lighting design.

Light is critical to human activity in that it allows us to see things and perform tasks. It is also important because it affects human beings psychologically and physiologically.

Several studies have documented the importance of light in reducing depression, decreasing fatigue, improving alertness, modulating circadian rhythms, and treating conditions such as jaundice among infants (Ulrich, Zimring, Joseph, Quan, & Choudhary, 2004).

Further, the presence of windows in the workplace and access to daylight have been linked with increased satisfaction with the work environment (Boyce, Hunter, & Howlett, 2003; Edwards & Torcellini, 2002). The behaviour of day lighting has not changed since its original use, but the building design to use it has.

Natural day lighting is often integrated into a building as an architectural statement and for energy savings. However, benefits from day lighting can extend beyond architecture and energy.

Numerous health problems such as seasonal affective disorder (SAD), headaches, breast cancer, and other ailments can be linked to poor lighting within this report. These symptoms are more obvious in some buildings than in others.

3 Literature Review of relevant material

3.1 Wavelengths of Light

Electrical light sources include cool white fluorescent, incandescent, energy-efficient fluorescent and full-spectrum fluorescent lighting. Each type has a

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different level of energy consumption. However, the most important factor affecting building occupants is the different spectrums of light that each source produces.

Different wavelengths or spectral distributions of light have different effects on the human body. Most electrical light sources lack the spectral distribution needed for complete natural functions, although full-spectrum fluorescent lighting does come close to that of natural light (Hathaway, et al. 1992).

Cool white fluorescent lights are concentrated in the yellow to red end of the visible light spectrum. Incandescent lamps, similarly, are concentrated in the orange to red end of the spectrum. In comparison, energy-efficient fluorescent lighting is typically concentrated in the yellow to green portion of the spectrum. These three light sources lack the blue portion of the colour spectrum (Liberman 1991), which is the most important part for humans and is best provided by natural light. Full-spectrum fluorescent lighting is the electrical light source that has a spectrum of light most similar to natural light because it provides light in the blue portion of the spectrum.

Daylight provides a better lighting environment than cool white or energy-efficient fluorescent electrical light sources because “ daylight...most closely matches the visual response that, through evolution, humans have come to compare with all other light” (Franta and Anstead 1994). The majority of humans prefer a daylit environment because sunlight consists of a balanced spectrum of colour, with its energy peaking slightly in the blue-green area of the visible spectrum (Liberman 1991). According to Hathaway, et al. (1992),

natural light also has the highest levels of light needed for biological functions:

The photo biologic action spectrum of greatest importance to humans ranges from 290 to 770 nm. Skin reddening and vitamin D synthesis occurs in the range of 290 to 315nm. Tanning or pigmentation of the skin and reduction of dental [cavities] occurs in response to band light in the band from 280 to 400 nm. Vision is the most sensitive to light in the 500- to 650- nanometer range (yellow-green light). Billirubin (jaundice) degradation occurs in response to light in the 400- to 500-nanometer range (blue light) (Hathway, et al. 1992).

3. 2 Effects of Light on the Body

Humans are affected both psychologically and physiologically by the different spectrums provided by the various types of light. These effects are the less quantifiable and easily overlooked benefits of day lighting. Natural lighting has been associated with improved mood, enhanced morale, lower fatigue, and reduced eyestrain. One of the important psychological aspects from day lighting is meeting a need for contact with the outside living environment (Robbins 1986).

According to Dr. Ott (Ott Biolight Systems, Inc. 1997a), the body uses light as a nutrient for metabolic processes similar to water or food. Natural light stimulates essential biological functions in the brain and is divided into colours that are vital to our health. On a cloudy day or under poor lighting conditions, the inability to perceive the colours from light can affect our mood and energy level. Dr. Liberman (1994) also mentioned that light plays a role in maintaining health:

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3.3 How the Eye Works

The human eye functions at its best when it receives the full-spectrum of light provided by daylight (A Closer Look at Day lighted Schools 1998). Many fluorescent lights are concentrated in the yellow-green portion of the spectrum to obtain the most lumens per watt; this unbalanced, narrow spectrum limits the blue in the source, which leads to improper functioning of the eye. Therefore, the superior spectral content of natural light makes it the best light for the eye (Ott Biolight Systems, Inc. 1997a). Looking at what parts of the eye are affected by light helps to understand how it functions in different light sources:

The human eye is a light-sensing system with a pupil and a retina. The retina contains two photoreceptors: rods and cones. Cones (which see photopic lumens or bright light) are responsible for day vision. Rods (which see scotopic lumens or dim light) are associated with night vision. Studies at UC Berkeley Laboratories by Dr. Sam Berman, senior scientist, have proven that pupil size and brightness perception at typical office levels are, in fact, strongly affected by rod activity within the retina of the eye.

Light reaching the retina of the eye is converted into electrical signals that are transmitted by the optic nerve. Most of these signals end up in the visual cortex of the brain and produce our sense of vision. However, some of the nerve fibres split off from the optic nerve soon after leaving the eye and send signals to the suprachiasmatic nucleus, which is the area of the brain where the main clock for the human body resides (Light, Sight, and Photobiology 1998).

3. 4 Effects of Light on Internal Body Systems

Wavelengths of light help control the human body's chemistry (Ott Biolight Systems, Inc. 1997a). Many functions, including the nervous system, circadian rhythms, pituitary gland, endocrine system, and the pineal gland are affected by different wavelengths of light.

3. 4. 1 Nervous and Endocrine System

Both the central nervous system and the neuroendocrine hormonal system are influenced by the influential stimulus of light (Ott 1982; Brody 1981; Wurtman 1975; Kotzsch 1988). Wurtman (A Summary of Light-Related Studies 1992) claimed that light has biological effects important to health and that some of these effects could be measured in a laboratory.

The effects of light fall into two categories: those modifying individual endocrine, hormone, and metabolic state by light reaching the retina and those resulting from light on the skin. Some effects of light on the skin are vitamin D production, skin tanning, and dissociation of Jaundice.

3. 4. 2 Circadian Cycles

Light falling on the retina and being transmitted to the hypothalamus controls our

circadian rhythms (Samuels 1990), which is responsible for synchronizing our internal clock to 24 hours (Light, Sight, and Photobiology 1998). The effects of light on circadian rhythms can be studied using physiological variables such as the daily patterns of core body temperature, levels of melatonin,

urine production, cortex activity, and alertness (Light, Slight, and Photobiology 1998).

In 1980, Bickford noted that prolonged exposure to cool white fluorescent lights might induce abnormal circadian rhythms because the hypothalamic pace making mechanism is thought to react to all the colour frequencies. Other lighting studies have shown that the light absorbed by the eye controls the production of the hormone melatonin, which affects sleep, mood, body temperature, puberty onset, and tumour development (Salares and Russell 1996). By looking at the purpose of an internal 24-hour clock, the significance of circadian rhythms can also be seen.

The circadian system is organised neurologically to drive bodily functions up and down every day and is a pervasive physiological regulatory mechanism. The timing of such circadian rhythms as body temperature is independent of precise knowledge of external clock time, and in the absence of periodic environmental cues, the internal clock produces a “ subjective” day length that differs reliably from 24 hours.

Humans living under experimental isolation conditions may cycle at lengths greater than 24 hours. This kind of deviation would pose the risk of continual lack of synchrony with the external world were it not for the ability of light to force a daily correction in the internal clock and a strict match to 24. 00 hours (Terman, et al. 1986).

Among the hormone activities that closely follow 24-hour cycles, the secretion of melatonin from the pineal gland (which induces sleep, modifies mood and mental agility, and plays its part in the activities of the

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reproduction system) is the most notable. Secretion of melatonin is closely followed by cortisol emission from the adrenal cortex (which affects the breaking down of carbohydrates, protein and fat; the development of white blood cells; the activity of the nervous system; and the regulation of blood pressure)(Bryan 1998).

3. 4. 3 Pineal and Pituitary Glands

Wurtman linked light entering the eye with responses of the pineal gland and secretion of the hormone melatonin in 1968; this hormone also influences the functions of other glands from direct action on specific areas of the brain (A Summary of Light-Related Studies 1992). Studies have shown how melatonin production affects human health.

Melatonin is normally secreted by the gland in the absence of light and where daylight and artificial lighting in the interior of buildings are inadequate the natural suppression of melatonin production during the day fails and is accompanied by feelings of depression (Wurtman 1975; Liberman 1985; Lewy 1985). Melatonin levels in the body determine a person's activity and energy level. High melatonin levels cause drowsiness, while low melatonin levels correspond to an alert state of consciousness (Ott Biolight Systems 1997a).

3. 4. 4 Seasonal Affective Disorder (SAD)

SAD has been one of the most researched areas in the illnesses that light affects. SAD is attributed to a variety of recurring events, but has been clearly attributed to the amount of light available for individuals. Without the proper amount of light available, our circadian rhythms are affected and a

weakness to SAD is increased. SAD occurrences are dependent on the availability of outdoor light in the winter and latitude. Although this condition is seen primarily in adults between the ages of 20 and 40, children have also been found to suffer from this condition. For them, the bad temper, fatigue, and sadness are frequently accompanied by a decline in concentration and school performance (Lieberman 1991). Because the availability of outdoor light affects SAD occurrences, light can play a vital role in preventing and curing SAD. Terman, et al. (1986) explained the importance of light in curing SAD.

3. 5 Effect of light within Buildings and Offices

Studies show that the proper use of natural day lighting decreases the occurrence of headaches, SAD, and eyestrain (Franta and Anstead 1994). Headaches and SAD are related to inadequate light levels. These ailments are reduced when the lighting level is improved by using correct spectral light. However, the number one health problem in offices is eyestrain (Ott Biolight Systems, Inc. 1997a).

Another important yet simple effect from day lighting could be a more positive mood for employees. Increased job satisfaction, work involvement, motivation, organisational attachment, and lowered absenteeism could result from an improved mood (Heerwagen, et al. 1998). In 1988, Clark and Watson found that negative moods are associated with discomfort and distraction, whereas positive moods are associated with the physical setting at work and daily activities such as social interactions among employees. Owen Bailey (Bruening), research associate at the Rocky Mountain Institute,

said, “ If you improve the space that employees work in, then they are likely to be happier, healthier, and more productive.”

3. 5. 1 Productivity in the Office (case study)

Pennsylvania Power and Light installed high-efficiency lamps and ballasts in the early 1980s to reduce glare for drafting engineers. The effects from the low-quality lights previously used were not only causing glare, but also morale problems, eye strain, headaches, and increased sick leave for employees (Lovins 1995). With improved lighting, productivity for the drafting engineers increased by 13. 2% (Lovins 1995). Previously, the drafters took 6. 93 hours on average to complete one drawing, which results in 0. 144 drawings per hour. The upgrade decreased the time to complete one drawing to 6. 15 hours, which increased productivity to 0. 163 drawings per hour

(Lovins 1995). The lighting retrofit also resulted in a decrease in sick leave from 72 hours to 54 hours per year, a difference of 25% (Lovins 1995).

3. 5. 2 Absenteeism in the Office

Some companies have seen a reduction in office worker absenteeism after moving to new office buildings that integrated daylight. Lockheed Martin, the International Netherlands Group (ING) Bank, and Vodafone are a few of these companies.

In 1983, when Lockheed Martin moved some of its California employees into a daylight building, a 15% decrease in absenteeism from the old building was witnessed (Romm and Browning 1994).

3. 5. 3 Day lighting in Schools

School children and teachers can benefit from integrating and managing natural daylight properly. Reported benefits include reduced utility costs for schools, improved student attendance and academic performance, and a less stressful environment for students.

A Daystar article, “ Benefits of Natural Day lighting”(1998), suggested that there is increased student and teacher attendance, increased achievement rates, reduced fatigue factors, improved student health, and enhancement of general development. Additionally, natural day lighting eliminates noise and flickering from light fittings and provides the best quality of light available in gymnasiums, classrooms and corridors. Research has shown that students in windowless classrooms are more hostile, hesitant, and maladjusted. Also, students in windowless classrooms tend to be less interested in their work and complain more. (Nicklas and Bailey 1996)

A school with insufficient light can also reduce a student’s ability to learn due to the effect lighting has on physiology. Poor spectral light can create strain on students’ eyes, leading to a decrease in information processing and learning ability, causing higher stress levels (Lieberman 1991).

Daylight also produces ultraviolet radiation. Dr. Ott claims, “ trace amounts of certain wavelengths of light...can have a surprising affect on your health” (Lieberman 1991).

3. 5. 4 Day lighting in Health Care Facilities

Reported benefits that by use natural light in hospitals has reduced lighting and heating costs as well as improved physiological and psychological states for both patients and staff. Studies show that day lighting can reduce the mental and physical strain of patients, doctors, and nurses.

Day lighting has been so successful that hospital environments, it is now also being used t as part of the patient recovery program in many health care facilities and, assisted-living communities are also integrating day lighting because it provides better light.

“ Day lighting offers a sense of spirituality, openness, and freedom from the prison-like confinements and intensity that characterize windowless spaces” (Verderber 1983).

The effect of light in hospitals is why German hospitals and medical facilities banned the use of cool-white fluorescent lights (Walker 1998). The benefits of day lighting and the feeling of openness extend to the staff, visitors, and patients.

5 Conclusions and Implications for practice

From the studies within this report the author has concluded that there is sufficient evidence to link natural lighting provision to the mental health and general well being of building occupants, and also Natural daylight does have an impact on human health and performance by enabling performance of visual tasks, controlling the body’s circadian system, affecting mood and perception, and by enabling critical chemical reactions in the body.

It is imperative to make the most out of natural day light and then artificial lighting. They all need to comply with safety aspects and recommendations. When designing buildings, emphasis is placed on construction and maintenance costs. However, real people will be working in these buildings, so consideration should be given to their psychological and physiological well-being.

The improved health of building occupants benefits employers and building owners because of improved performance. With correctly installed and maintained day lighting systems, natural light has proved to be beneficial for the health, productivity, and safety of building occupants. Natural light helps maintain good health and can cure some medical ailments.

The enjoyable environment created by natural light reduces stress levels for office workers. Productivity increases with the improved health of workers, and with better productivity comes financial benefits for employers. Students also perform better with natural light. All over the world, studies have shown students in natural daylight rooms achieve higher test scores than students in windowless or poorly lit classrooms. Along with better test scores, student health also improves from the increase in vitamin D intake.

Students have fewer dental cavities and grow more under full-spectrum lighting. Day lighting also benefits retail stores because of more even light that provides better colour rendering. Customers stay in stores longer and employees can identify items faster with better lighting. In hospitals, natural light improves patient recovery rates and allows for proper vision for the elderly in assisted living facilities.

Hospital staff also benefit from the natural light because of the amiable environment. Patients will be more at ease when staff is in a better mood, and the staff will be calmer when patients have improved recovery.

Productivity increases in industrial environments because of improved colour rendering and the better quality of light provided by natural light. Also, safety is increased with better lighting conditions. The use of day lighting decreases utility costs and improves the well-being of building occupants.

Adequate and appropriate exposure to light is critical for health and well-being of patients as well as staff in healthcare settings. A combination of daylight and electric light can meet these needs. Natural light should be incorporated into lighting design in healthcare settings, not only because it is beneficial to patients and staff, but also because it is light delivered at no cost and in a form that most people prefer.