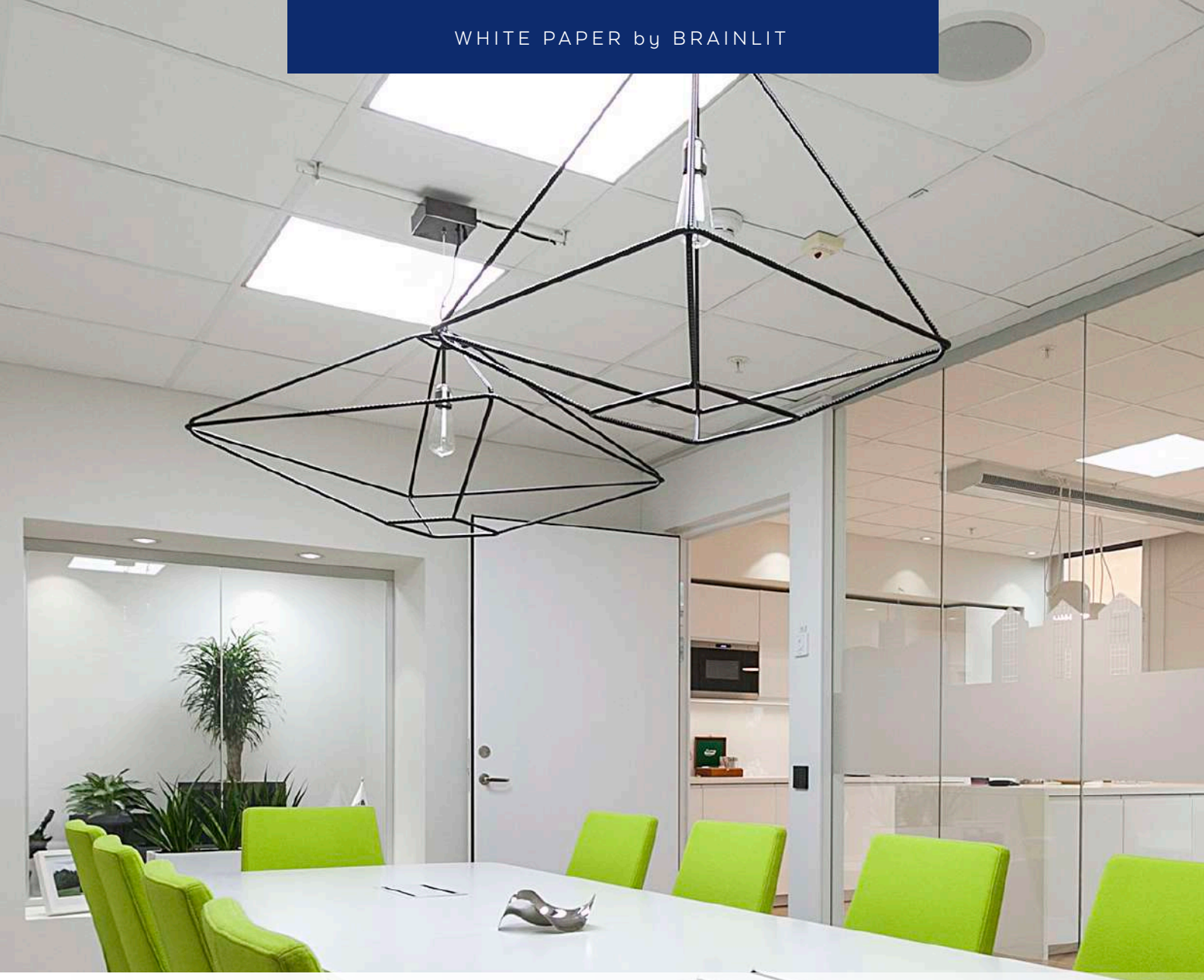
WHITE PAPER by BRAINLIT



OFFICE

Lighting as a tool in the professional workplace

BRAINLIT

BIOCENTRIC LIGHTING IN OFFICE

An increasing knowledge of the importance of the lighting environments influence on wellbeing, learning and sleep has created a shift in how we look at lighting. The lighting environment in offices has traditionally been focused on ergonomy and visual function. But light is not only for vision. In the retina a subpopulation of ganglion cells play an important function in synchronizing the body with the solar day.

Fluorescent lighting systems are still the most prevalent sources of illumination in offices. By their physical nature, they don't provide the wavelengths necessary to entrain the daily rhythm that is needed to synchronize the sleep/wake rhythm with the solar day. Lighting conditions must create conditions that motivate employees and improve their wellbeing. New research has pointed out the importance of light as an enabler in the office environment and important synchronizer of circadian rhythm and sleep.

Light, and especially blue light, exerts an alerting effect on the human brain. In an experiment with 21 individuals, 1 hour exposure to 40 lx blue light (470 nm) was found to be as effective as 240 mg caffeine in a reaction test and the blue light outperformed caffeine when both congruent and incongruent distractions were presented[1].

In another study, blue enriched morning light showed acute wake-promoting effects and faster reaction times than with warm-white light from incandescent bulbs where some of these effects persisted until the evening[2]. The blue-enriched light was also shown to be protective against the melatonin-suppressing light at night.

The alerting effect of short-wavelength light has thus led to the suggestion that light can be used as a non-pharmacological countermeasure for sleepiness and to improve reaction times among employees. It could also be an effective tool in specific demanding work situations where attention is vital.

Light in a continuous learning organization

Not only does light evoke an alerting effect on exposure. Light can also positively affect cognitive working memory after such light exposure.

In a study with healthy participants exposure of 30 min of blue (469 nm) light but not amber (578 nm) light had a beneficial effect on reaction times and short term memory when tested 30 min after the light exposure. This improved cognitive performance was also accompanied with an increased activity in the prefrontal cortex in the brain as examined with functional magnetic resonance imaging[3].

Activities in the hippocampal area in the midbrain and the prefrontal cortex, areas in the brain important for alertness and learning, has been reported after blue light exposure. MRI-experiments illustrating increased activity in these specific brain regions have shown that light can modulate brain responses to cognitive tasks already after a few minutes exposure[4].

That the light source and thus the wavelength is important is shown in several studies. In one study, faster reaction times on a cognitive task was found with LED lighting compared to fluorescent lighting conditions[5] and in a study by Ferlazzo et al. comparing halogen light with LED lighting, better scores were attained on a complex visual-spatial ability task with LED lighting[5]. Both fluorescent and halogen are scarce in the important shorter wavelengths around 460-480 nm.

Light exposure has been shown also to be able to positively modulate the results during a more demanding task such as repeating several numbers backwards where higher light intensity yielded better results[6].

Light has a positive impact on mood

Bright light indoors can increase the level of vitality and energy. It can also decrease the intensity of depressive symptoms even in persons not having seasonal change sin mood or behavior[7].

It has been shown in experiments with MRI chambers that light affect
areas in the brain important for our feelings[4].

Adequate lighting is associated with a feeling of happiness while dark lighting induces feelings of depression.

Blue-toned white light has shown a direct subjective mood enhancing effect[8] and when adults rate their mood, it is the blue light that is given the highest mood scores[9].

Many of us are sleep deprived

In the evening the sleep hormone melatonin makes us tired and it peaks in the middle of the night. When we wake up, daylight has a suppressing effect on the release of melatonin and we feel wake and alert.

This circadian sleep-wake rhythm needs to be aligned with light daily not to fall out of sync with the solar day. Our modern lifestyle with 90 % of time spent indoors, most of the time provides insufficient light for synchronization with the solar day.

Without this synchronization, the release of melatonin in the evening gets delayed and sleep gets pushed to a later hour. A viscous circle with later bedtime and less sleep becomes the result as is often seen among urban people.

We have diminished our sleep by 1 hour only the last 10 years and most of us get less than the required 7 hours of sleep per night[10]. Adequate sleep is necessary to be able to focus attention on what is to be learned. But sleep is also important for the consolidation of memories, which is essential for learning.

Sleep deprivation leaves the brain exhausted and makes it more difficult to concentrate and learn new things. Without adequate sleep, neurons can no longer coordinate information properly and we loose our ability to access previously learned information[10].

Also, in the long term lack of sleep is a problem, as sleep deprivation may lead to obesity, diabetes and cardiovascular disease[10].

Lighting conditions in modern offices often follow building norms. These norms do not take into consideration the need of light for synchronization of the circadian rhythm.

Light to restore a disturbed sleep

When activated with light, the retina and more precisely a subpopulation of retinal ganglion cells, send signals to time-keeping centra located in the suprachiasmatic nuclei, the Master clock, in the hypothalamus in the brain that uses this information to direct the body for its daily activities.

When stimulated, the brain gets alert and the body clock is set to daytime and productivity mode. This time-keeping system also influences our circadian sleep/wake cycle. For it to be efficient, it needs enough light to be activated, often more light than is needed

for vision. Furthermore, the system is more sensitive to light with shorter bluer wavelengths[11].

The timing of light is also important as exposure to blue light sources, as those in handheld devices at night, is detrimental to the circadian rhythm as this confuses the system in believing it is daytime.

The human circadian system is also influenced by prior lighting environment. Light during daytime can protect against aberrant light in the evening. Studies has shown that 900 lx of white light (4523 K) or 79 lx of bluish white light (9584K) in the first half of the day were enough to protect against 90 min night light exposure (300 lx), that would otherwise have induced a suppression of night-time melatonin[13, 14].

Dynamic light

Different office light conditions can directly influence alertness and productivity as shown above but can also affect parameters important for sleep. Studies among office workers have shown that those who receive light that stimulates the circadian system, especially during the first half of the working day, have an increased sleep quality and reduced sleep onset latency[14].

Taking the knowledge regarding human physiology further, researchers are also investigating the effect of dynamic lighting environments. In one experiment such an environment was shown to be superior to constant light (400 lx 5 000 K) and equivalent to intense light (750 lx 5 000 K) in producing correct answers in a response time task.

on top of this, test subjects in the dynamic lighting environment showed higher levels of melatonin at night beneficial for sleep. According to the authors this could be due to dynamic light mimicking daylight, whereas a constant intensity light would make the circadian sleep/wake rhythm vague.

Another interesting fact the researchers reported was that with dynamic light no "post lunch dip" was seen as in all the other lighting conditions[15]. Disrupting sleepiness during the post-lunch dip may result in a decrease in human errors and accidents.

Lighting as a tool at the workplace

Project work, informal communication and networking are increasingly shaping everyday office work. Light is important to entrain the diurnal rhythm, but also to optimize working environment.

In the newly built office building "The Spark" in Medicon Village in Lund, Sweden, the employees are using BCL™ in their workday to support efficient use of office space.

In the standard setting the light changes dynamically in a day-like manner. In the conference rooms different settings can be chosen based on the activities. "Activity" setting is chosen for brainstorming sessions; the light is more intense and with a higher CCT.

The light changes when information is presented on the screen in the conference rooms, "Smartboard"; middle intensity and a somewhat warmer color temperature. "Relax" can be chosen for socializing; a lower intensity and a warmer color temperature is then used.

Summary

- Light can promote alertness and improve cognition
- Light has a positive impact on mood
- Many people are sleep deprived
- Most workplace have inadequate lighting
- Adequate lighting promotes sleep and wellbeing
- Light can be a tool in the workplace

Lighting plays a key role in helping to create an efficient office environment to ensure that employees reach their full potential. Lighting within a room influences our state of mood and lighting environments must create conditions that motivates and promotes wellbeing.

With BioCentric Lighting™ (BCL™), interior light can be controlled so that it dynamically changes during the day in the way daylight does and provides synchronization with the bodily rhythms.

The BioCentric Lighting™ system is easily customized according to the unique needs of the individual workplace. The light environment provides the employees and staff with the light that they need each day, regardless of season. This research is still evolving and continues to provide new understandings of the beneficial effects of different lighting environments in an office setting. The BCL™ system is easily adaptable to meet these new insights.

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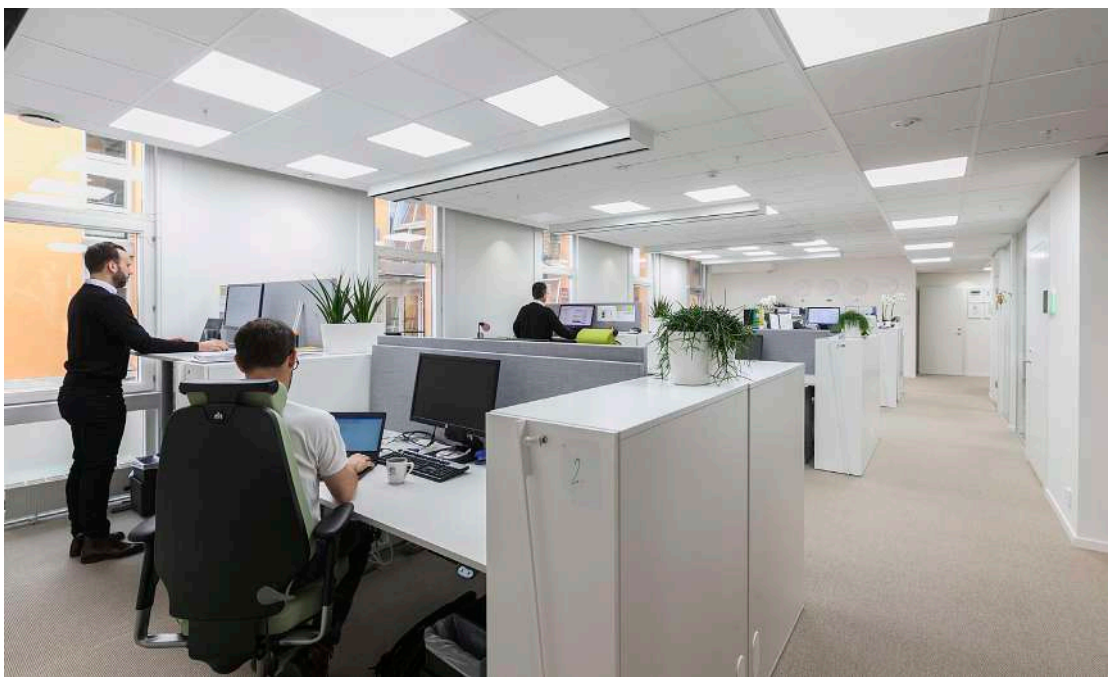

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