The attributes of light

…and what remains in the office space.

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As lighting designers we have all given thought to the effect of light on human beings and the biological, physiological and psychological processes it can trigger. As users we take what light is offered us more or less for granted. And we all know that poor lighting, especially at the workplace, can be the cause of poor productivity or even health disorders.

The effect that light can have on human beings is very varied, starting with the probably most important function of conveying visual information to the eye and thus rendering things around us perceptible. In this regard, our tolerance of the varying quantities and qualities of light is incredibly high. This is because the eye-to-brain system which supports human perception is extraordinarily adaptable. What does that mean in effect? The further removed the lighting conditions are from the ideal situation – taking diffuse daylight to be the ideal – the more our perceptual system needs to adapt. The human organism requires energy to adapt. Since we require 25 per cent of our overall energy for the process of perception, it is not hard to imagine that higher percentages of energy are consumed when we are performing demanding or complex visual tasks. After two hours in a museum studying fine line drawings visitors will set out to locate the cafeteria to recharge their batteries, or at least have a visual break from scrutinizing the graphic works of art!

Absorbing information, comparing and recognizing it, then aligning it with data already received: all this makes for an extremely energy consuming process. The more information we take in by means of visual perception, the higher the number of connections that are required in the brain. This consumes large amounts of energy on the one hand but naturally results in a gain of additional knowledge on the other. A human being with normal eyesight retrieves around 80 per cent of the knowledge gained from his visual environment via the visual senses. Light enables the eye to retrieve this information. For this reason, light is also often referred to as the source of all knowledge.

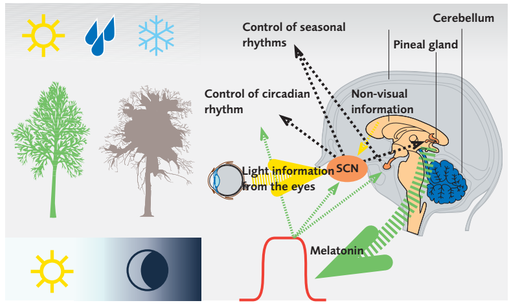
Light is the symbol of life, both metaphorically and factually speaking, because all living things need light to thrive and prosper – light as a life-giver, and not only for lower life forms, photosynthesis and similar processes, but also to fuel all processes required to keep the human body functioning. Animals are likewise subject to this law of nature to a large extent. After all, over 90 per cent of human genes are congruent with those of animals. Indeed, 98 per cent of our genes correspond to those of apes.

All processes in our bodies related to biorhythms are activated, triggered or controlled naturally by daylight. Admitted through the eye, forwarded to the brain, controlled via various glands in the brain, relayed via our autonomous nervous system, natural light steers the processes in our biological energy balance, as well as in our growth and maturity, and for our circulation and breathing. Daylight influences our feelings, reproduction, body temperature and periods when we are awake or need to sleep. Even different seasonal activities are steered by daylight. The fifth receptor in the eye, which was only discovered by neurobiologist David Berson in 2002, is responsible for the way the eye admits information about light and converts it into electric signals to be relayed to the brain. It is this receptor that plays a significant role in controlling the production of melatonin. This receptor is not dedicated to vision, but incorporates an additional receptor that absorbs light via the photopigment melanopsin and, by means of a biochemical process, controls the pineal gland, which is located in the brain and produces the hormone melatonin. Our circadian rhythm, which regulates all our bodily functions, relies on signals sent out by this receptor.

Light enables our internal clock. It regulates our waking and sleeping times. If human beings are enclosed in spaces without daylight for longer periods of time, their 24-hour rhythm will readjust to a fixed cycle of between 23 and 25 hours depending on the individual. If we envision a modern-day office worker who, depending on the time of year, is practically independent of daylight for around eight hours a day, you do not have to be a genius to recognize that this must have a hugely negative effect on the above-mentioned natural bodily processes. Undermining or disturbing our natural rhythms on a permanent basis can have short and long-term consequences. In the short term, office workers may complain of headaches, listlessness or unproductiveness, in the long term they generally begin to suffer from sleep disorders or may even contract serious illnesses such as cancer. People who work night shifts are even more extremely affected, because they are working at times that are completely contrary to their natural rhythm. Studies have shown that the chances of people working at night contracting cancer as a result of suppressed melatonin production and the inherent bodily malfunctions and disorders is 35 per cent higher than that of persons living in accordance with their natural biorhythm. Night work is therefore only acceptable in the case of emergencies and if carried out in shifts. Given the scientific findings available to us today, anything else borders on bodily harm.

There are ways of easing the situation: dynamic, colour changing lighting at the workplace can provide relief and support human requirements. To give workers an impression of changing daylight conditions over the day or to support that impression in areas that do not receive sufficient daylight, the electric light must be adapted continually to generate as natural a sequence as possible.

Thanks to the eye's ability to adapt to changing lighting conditions, we are hardly aware of these qualitative and quantitative changes throughout the day. Our perceptual system uses this mechanism to enable us to best perceive our surroundings



The control of melatonin secretion is dependent on daylight.

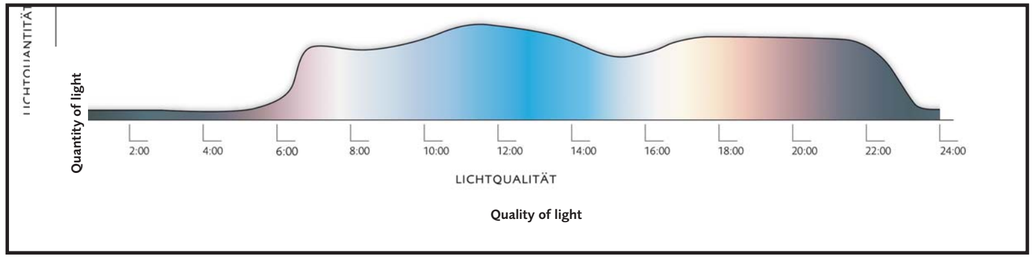


Illustration 2: Quantitative and qualitative changes within 24 hours.

regardless of the prevailing lighting conditions. Tests carried out under purposefully designed dynamic lighting installations show that workers' attention and productivity during working hours can be raised, breaks are enjoyed more, and they are able to rest and sleep better. Periods of rest are needed for regenerating bodily functions and organs, and are thus extremely important for our health and well-being. Periods of sleep after dark are ideal to support this regeneration process. Rest and recuperation during the daytime has limited effect, if any at all. According to recent research results, one prerequisite for a good night's sleep is at least three hours of unfiltered daylight during the daytime. This presents many people with a real dilemma: office workers who cannot leave the office for long periods of time, and especially night workers, of course.

Human beings only register changes in the intensity and above all quality of the light if they occur suddenly and when as a result the visual system is not able to adapt fast enough. Tests whereby office workers can adjust the colour and intensity of the light individually are therefore dubious, since they address the ability of the eye to adapt, although users tend to favour such schemes because they allow individual interference. Such concepts are also open to criticism because of the lighting effect generated by the entire building, both inside and when viewed from the outside.

Since the majority of office spaces use electric light, it is important that the spectrum of the light sources applied is as continuous as possible. The quality of the lighting in offices using fluorescent technology can only be improved by combining the fluorescent lamps with other light sources. Attention should be paid to the influence of blue and ultra-violet rays on the human organism, since this part of the spectrum is where the reception range of the fifth receptor is located. This receptor plays a significant role in regulating our night and day rhythm via the pineal gland. The production of melatonin, which is frequently wrongly referred to as the sleep hormone (melatonin only regulates our biorhythm and not our sleep patterns and is thus a regulatory hormone) by the pineal gland is suppressed by light – and in this case especially shortwave light and UV radiation in the non-visible part of the spectrum. These spectral components are evident in the light generated by fluorescent lamps. The effect of these wavelengths is that they make people active, or restless. This kind of light can have a negative effect over longer periods of time, because the body begins to produce cortisol. Cortisol is often described as a stress hormone; it makes us alert. What we need to relax is warm light, that is to say light from the warmer part of the spectrum, and if possible indirect – bounced off a surface.

The red components, which serve to regenerate our nerve cells, are at the other end of the spectrum. All non-reproducible cells, such as nerve cells which include especially sense-related cells, are stimulated to regenerate thanks to the red light. Here lies one of the most serious problems when it comes to the application of fluorescent technology, which incorporates practically no red components at all. Even combinations of fluorescent lamps on the basis of additive colour mixing in red, green and blue comes nowhere near to producing good results, because the gaps in the spectrum still remain.

The optimum for an electric lighting installation would be to combine fluorescent lamps with incandescent lamps, which have a continuous spectrum with high red content and low blue content. This solution is generally not feasible in the office environment because of the inherent costs. Room for development here for lamp and luminaire manufacturers, plus enormous potential for development on the part of the designers. The industry needs to focus more strongly on the development of lighting products that serve man's biological needs. Some luminaire manufacturers have got the message already, thus demanding more of the manufacturers of light sources to invest more development potential into this part of the industry. In times when conventional incandescent lamps are already being phased out in certain countries, there should be an outcry among lamp manufacturers, and their research and development departments need to concentrate their efforts in this direction. It is important to note that photobiologists are still warning us about dynamic lighting installations or the use of electric light for what they term "photo-doping", which boils down to treating people with large quantities of cold colour temperature light, since there is no data available on tests carried out over long periods of time. It would make sense to pursue research activities supported by multidisciplinary teams.

From the architectural standpoint, there needs to be a turnaround in the way to address solar and thermal protection for office buildings. We need to get away from architectural elements designed to cast shadows in glazed facades, or solar protection devices added subsequent to completion of the building – all made more or less to fulfil the required norms. Architecture must be designed in alignment with daylight: not primarily to shut it out, but to use it intelligently as part of the architectural design. This does not mean re-promoting glass architecture, which allows diffuse daylight to penetrate the reflective glazing and reach every corner of every space, eliminating practically all shadow. The frequent use of solar glazing, which predominantly filters out the infrared and red components of the spectrum and thus avoids heat build-up in the interior of the building, could not be further from wrong, given what we know about the all too important biological effects of light. Unless all office workers surrounded by such glazing are ordered to spend a few hours every day outside in natural daylight and encouraged to read of an evening under a good old incandescent lamp.

When it comes to permanent workplaces and areas of recreation within the working environment, the daily daylight requirements need to be given higher priority than the position of the computer screen and how to restrict reflected glare. The standards need to be reviewed and redefined instead of calculated on a computer. In every new museum the direction the openings are facing is defined according to the direction the building is facing; many factors are taken into account including the culture, history and the degree of sensitivity of the object to be illuminated. The architectural design is aligned to daylight. Electric light is used sensitively where and when required. When we begin to pay more attention to the way a painting in a museum is lit rather than to the needs of the people who work there, there is definitely something wrong! It is up to the lighting designers to assert themselves more vis-à-vis clients and architects and to design electric light in office spaces to complement daylight instead of making it the basis of the lighting design. As lighting designers, we should be alarmed at the way daylight design and designing with electric light are drifting further and further apart, and that there are increasingly more design practices that specialize in one or the other. This trend promotes a divided approach to designing with what is actually one medium.

In a large majority of projects it is the client or the user who, understandably focussing on keeping costs to a minimum, stands in the way of good lighting design. A new sensitivity is called for based on and in the interest of the well-being, and thus productivity, of the worker. Productivity is a prime economic factor. Mens sana in corpore sano: a healthy spirit works better in a healthy body!

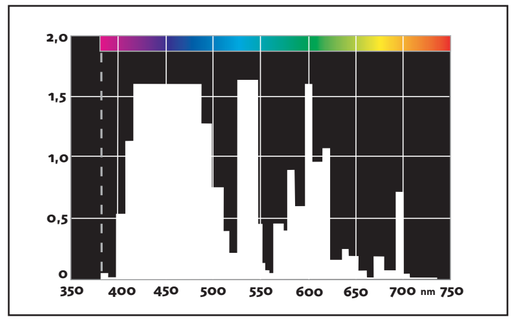


Illustration 3: RGB mixing using fluorescent lamps.