Artificial Light and Health - A Plea for the Incandescent Lamp

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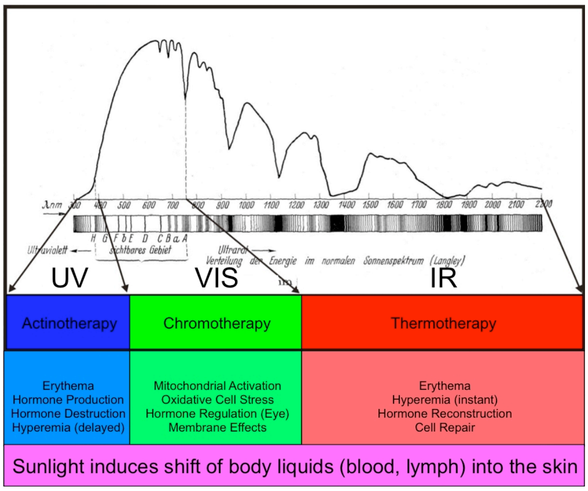
Summary

Artificial light brings a large number of benefits to modern civilization, but there are some aspects which indicate that it is necessary to be careful with the selection of light sources. Energy efficiency plays the main role in recent discussions, but are the light sources with the highest performance also the most healthy ones? Mercury-based fluorescent light sources, including so called "energy saving bulbs" as well as white LEDs with high colour temperature hold a great potential to interact with the human endocrine and circadian system, which can be detrimental for health under long term conditions. Since the complex light reactions in humans are now better understood, it is possible to select the spectral composition and electromagnetic properties of an artificial light source in order to avoid detrimental side effects and to achieve a maximum of positive effects on human health.

Introduction

Since the very beginning of life on earth, sunlight accompanied all biological processes and evolutions. Therefore, from the biological and also medical viewpoint, sunlight is the archetype of natural and healthy light. Life on earth is highly adapted to the spectral properties of sunlight. For humans there is another lightsource given by nature, which is the fire our predecessors and ancestors had in use since about 1,5 million years as a source of light and warmth. Sunlight and fire have an important common ground - both spectra are located on the Planck curve or black body curve. From the physiological point of view one can say that a radiation source behaves naturally, as long as the given spectrum follows the Planck curve. Using this definition, all light sources that we had in use until 1906, the year the mercury discharging lamp had been invented, were natural: chips of pinewood, blubber-oil lamps, candles, kerosene lamps, gaslight and even the incandescent and halogen lamps. The Planck curve enables us to predict the spectral distribution of a light source, as long as we know the temperature: All these classical artificial light sources show a very low content of ultraviolet radiation between 0 % (candle 1800 K) and 0,4 % (halogen lamp, 3200 K) compared to sunlight (> 11%, 5700K).



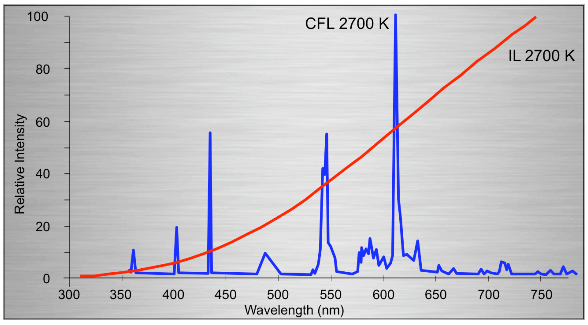
Tab. 1: Therapeutic ranges in sunlight spectrum

Light and Hormones

The sun spectrum can be split into three parts: UV, VIS and IR. The visible part is obvious, the other two parts are invisible - and this is the problem, nature had to solve: making the invisible parts detectable before they can unfold their destructive potential in the body rsp. on the skin. Hereby the IR part can be detected immediately by thermal receptors in the skin. The photochemical reactions induced by the UV are well known and examined, while the human body has no specific receptors for this kind of radiation. UV effects show a typical delay of several hours after exposure, which takes them out of reach of behavioural adaption. When you start to feel sunburn, it is too late for prevention, the reaction cascade is already running. The symptoms of the UV overdose are swelling and leakage of the dermal capillaries, inflammation, pain, destruction of dermal tissue, DNA and hormones. In case of severe sunburn up to 60% of the blood can be shifted into the skin, leading to a life-threatening circulatory shock state. In order to counteract those destructive effects, the system somehow has to foresee what could happen. Therefore it was practical that the sunlight spectrum follows the Planck curve: within this given framework the human system could develop a specific sensory system which is based on the factum that high content of UV radiation in nature is always linked to an even higher content of blue. The novel receptor system discovered by Brainard, Thapan and others is an extrapolative UV detection system based upon the reception of blue light in the ganglion cell layer of the retina. Some of these ganglion cells contain a pigment called melanopsin, which is receptible for blue rays, the absorption spectrum peaks around 460 nm. If the human retina detects bright light with a high content of blue, a cascade of endocrine reactions is triggered: Activation of the hypothalamus and the pituitary gland inducing a systemic stress reaction in the sympathetic part of the vegetative system and a suppression of the parasympathetic part including the activity of the pineal gland. In terms of physiology the two light factors, brightness and bluishness, induce a hormonal stress reaction capable of counteracting most of the destructive effects of the UV radiation.

Unnatural Light Sources

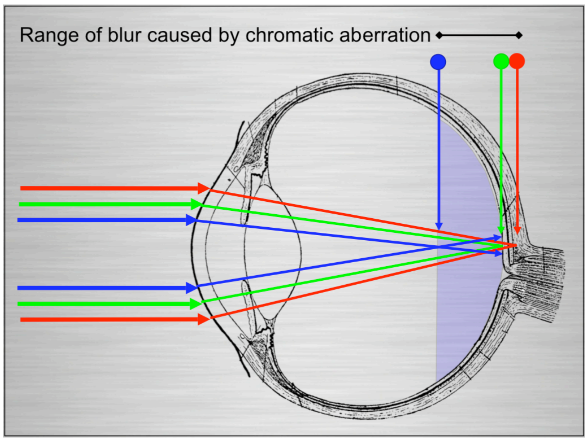
All light sources which do not follow the Planck curve in their spectral characteristics therefore can lead to a malfunction in the human endocrine system, as long as they produce bright light with a high content of blue rays. The correlated colour temperature (CCT) gives no valid information regarding the content of blue: even warmtone fluorescent lamps with a CCT of 2700 K show a unnatural peak in the blue part of the spectrum which is able to trigger the hormonal stress reaction. From the viewpoint of physiology it is highly recommendable to use incandescent light sources instead of fluorescent lights in order to avoid unwanted hormonal maladaption/malfunction.



Tab. 2: Spectral comparison of true color temperature (tCT) of an incandescent lamp (IL) and correlated color temperature (cCT) of compact fluorescent lamp (CFL).

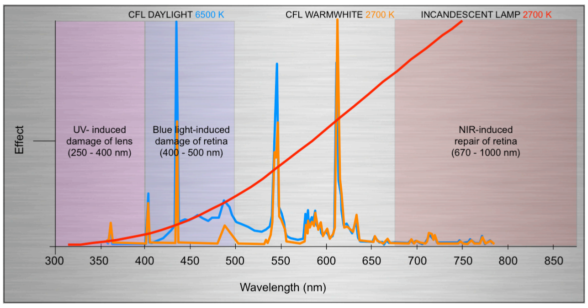
Blue Light and Vision

The human eye has two pathways for the processing of light signals. The optical part is responsible for vision processes while the energetic pathway controls the endocrine reactions via the retino-hypothalamic tract. For the purposes of vision it is better if the surrounding light does not contain high amounts of blue and violet wavelengths. The higher refraction for short wavelengths which occurs in optical media also appears in the eye. This causes a chromatic aberration effect with



Tab. 3: Chromatic aberration dependent from wavelength.

negative consequences for sharp vision. The different wavelengths focus on different planes in and around the focus plane of the retina. Due to photooxidative effects, the blue and violet radiation also promotes chemical reactions in the optical media of the eye and in the fovea centralis. We find a number of mechanisms in the eye which provide better vision on one hand and less photooxidative stress and damage on the other, in order to reduce the negative effects of blue light on vision. First the number of blue receptors is up to 20 times less compared to the number of red cones in the fovea centralis. Secondly there is a concentration of lutein, a yellow pigment which filters out excrecent portions of blue and shows also antioxidative properties. The concentration of this protection substance is reduced in the eyes of elderly people. Ophthalmologists have discovered that there is some evidence that the age related reduction of lutein is functionally compensated by the increased blur in the lens, which is also promoted by blue and ultraviolet light. As a consequence they replace the lens in cataract surgery by a colored one, which filters out the blue portions in order to protect the macula from further degeneration. This shows that even the structures of the eye wear out, depending on age and the amount and quality of light which has to be processed during a person's lifetime. The question is, is it only sunlight which is responsible for the increasing incidence of age related macular degeneration, which is found in 30% of the population over 70 years of age in industrialized nations? These people stay 90% of their time inside buildings while under the influence of artificial light, which has to be taken into account as well. We indeed find that there is a large and increasing number of fluorescent light sources in our environment which produce high amounts of photooxidative potent light, such as mercury vapor lamps with high color temperature, the backlight of TFT computer screens and TV sets.



Tab. 4: Spectral ranges responsible for retinal damage and repair correlated with spectral energy distribution of different lamp types.

The fluorescent lamp spectrum does not contain significant amounts of long wave radiation such as deep red or near infrared. A number of experiments with wavelength > 650 nm have shown that they have the potential to repair the oxidative damage caused by blue and violet light on cellular levels. Again - if we compare the spectral constitution of energy saving lamps and other fluorescent light sources with the incandescent lamp spectrum, the latter shows clear advantages in terms of better vision and retinal protection and repair.

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