The Institute for the Future of the mind

Light, attention and alertness

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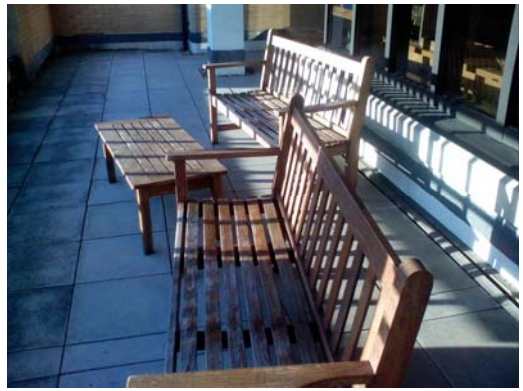

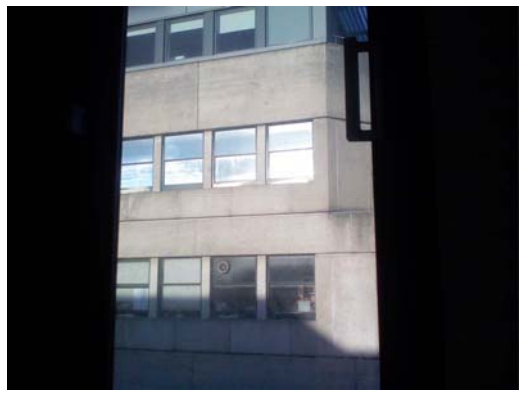

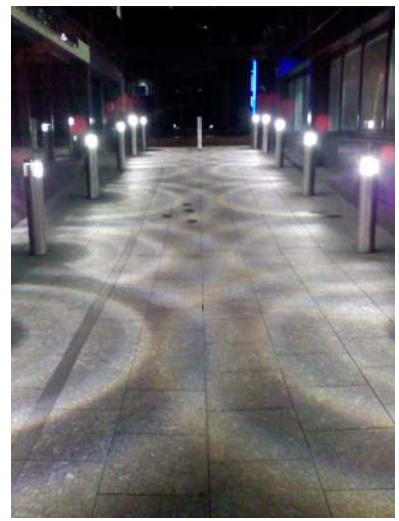

The science of light, attention and alertness

- Exposure to a specific band of blue light regulates our biological clocks
- Blue light makes people more alert and can improve visual perception
- An understanding of the non-visual effects of light might inform how learning spaces are designed

Blue light regulates our biological clocks

Our eyes are not just used to see. They also monitor light for the purpose of setting our biological clocks to a 24-hour day - the so-called circadian rhythm [1]. The biological clock has been shown to respond preferentially to light in a band of wavelengths in the *blue* end of the visible spectrum, which are close to the blue of a clear sky. Activation of specific receptors in the eye in the morning leads to a sequence of events in the brain that wakes us up and improves alertness. In the evening, when the available natural lighting moves towards more red tones, the brain releases hormones which cause us to be more relaxed and eventually leads to sleep. This process involves a part of the brain called the hypothalamus, which plays a key role in driving many of the daily cycles in the body, such as changes in metabolic activity and body temperature [1]. Controlling the circadian rhythm to light in this way works outside of the normal processing of light for sight; it is not activated by the usual receptor cells that trigger the visual process. This is neatly illustrated by the observation that some blind people can still regulate their circadian rhythms, despite having fully lost functional sight [2]. In essence, our eyes have effectively evolved to be blue-sky detectors.

Working under blue light

Recently, it has been demonstrated that blue-light directly improves alertness and performance in sleep-deprived subjects, compared to bright-green light - the colour of light to which sight is most sensitive [3]. Having disrupted subjects' sleep and circadian rhythms for six days, researchers found that exposure to blue light made subjects less sleepy, react faster and attend better on performance tasks. The research team concluded, "These findings add to the body of evidence that illustrates that there is a novel photoreceptor system that exists in the eye in addition to that used for sight. Light exposure to this system, particularly blue light, directly reduces sleepiness. Subjects exposed to blue light were able to sustain a high level of alertness during the night when usually people feel most sleepy."

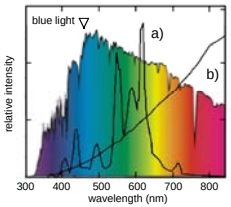

Fig. 1. A spectrum of natural daylight, showing a peak in the blue region. Natural fluorescent lighting (a) and tungsten filament lighting (b) emit weakly in this region.

Dyslexia - proven benefits of blue-light

Dyslexics have also shown to benefit from working under blue lighting conditions. By wearing blue filtered glasses, some dyslexics demonstrated a significant improvement in literacy levels compared to control groups. This is thought to work by boosting the signals in the brain which help control eye movements, required for effective processing of words when reading.

Designing learning spaces

The sensitivity of the biological clock to low-wavelength light is of particular interest when considering the lighting environments in schools; here, as in most indoor lit environments, fluorescent lighting is used which is predominantly weak in the blue end of the visible spectrum (see Figure 1). Consequently, the lack of blue light in conventional, fluorescent light may not represent the optimum lighting conditions for maintaining alertness in a classroom setting. Ensuring as much natural light as possible enters learning environments should prove beneficial, especially in the mornings when the biological clock is 'waking up' and being reset for the day ahead. Given the unpredictability of British weather, it may be possible to use daylight bulbs, which emit more strongly in the blue region of the spectrum, to achieve a similar effect.

The affect of light on circadian rhythms is also relevant when considering the use of computer display monitors and television screens, which can emit strongly in the blue region of the spectrum. Exposure to long periods of light from screens and monitors in the evening could possibly be activating the biological pacemaker and disrupting sleeping patterns.

References

[1] Brainard, G.C. and Hanifin, J.P. (2005) Photons, clocks and consciousness. *J. Biol. Rhythms* 20(4), 314-325

[2] Brainard, G.C. *et al.* (2001) Action spectrum for melatonin regulation in humans: Evidence for a novel photoreceptor. *J. Neurosci.* 21, 6405-6412

[3] Lockley, S.W. *et al.* (2006) Short-wavelength sensitivity for the direct effects of light on alertness, vigilance, and the waking electroencephalogram in humans. *Sleep* 29(2),161-8