

## Healthy Lighting for the Visual, Circadian and Perceptual Systems

a report by

**Milena Simeonova**

*Healthcare Facilities Committee, Illuminating Engineering Society of North America (IESNA)*

The healthcare system is in a process of transformation. Consumers are highly health-conscious and in search of healthy environments. Hospitals convert to centres of wellness, and organisational cultures focus on human factors. It would appear that the implementation of healthy lighting, satisfying the needs of the visual, circadian and perceptual systems, is a logical follow-up. Current hospital lighting, however, is designed for the visual system only. Lighting performance is determined by physical/photometrical measures for illuminance, flicker, glare, veiling reflections, spectrum, energy conservation, heat release and maintenance.

Research in light and health has confirmed that light not only serves the visual system but is also a powerful regulator of the circadian system and increases productivity, alertness and health and safety of patients and care-givers. *Table 1* shows a research summary on the lighting parameters for the visual and the circadian systems.<sup>1</sup> It is apparent that these parameters are contradictory.

Luckily, both systems operate at a different pace and can be simultaneously satisfied by introducing the time factor. The visual system is instantaneous, while the circadian system is slow to respond and the two systems interface through the perceptual constances and the square law curve for adaptation.<sup>2</sup>

The latest strides in photobiology research have produced lighting algorithms or lighting timelines. *Figure 1* shows a conceptual lighting algorithm.<sup>3</sup>

New light sources and fine-tuned controls are readily available to apply lighting for the visual and the circadian systems. The most critical need for circadian lighting is for elderly patients (over the age

of 65 years) and nurses. The elderly have a lesser amplitude of circadian rhythms and their energy levels and quality of sleep are decreased. Nurses have to perform cognitive tasks around the clock and usually lack daylight at their workstations.

Not as straightforward is the application of lighting for the perceptual system as perceptual qualities have no simple correspondence to the physical world.<sup>4</sup> Context, expectations, associations and perceived messages reconstruct the perceived world.

The complexity of lighting for the perceptual system is not understood. Complexity spurs from the great variability in human response.<sup>5</sup> Subject preference is unpredictable and varies between individuals and within the individual. It is important to find a stable positive framework that is perceived as such by the majority of people.

The biophilia hypothesis states that contact with nature and living things is an essential part of life for people. Research has confirmed that the view of landscape, rather than the availability of daylight, is healthy.<sup>6</sup> Most people experience a feeling of wellbeing when in contact with nature. Lighting for the perceptual system should be rooted in nature.

A word of caution: the success of even the most skilful application of healthy lighting depends on the presence of abstracted images of nature such as colour, texture, shapes and symbols of nature.

### Lighting Components for the Perceptual System

Some of the lighting components for the perceptual system follow.



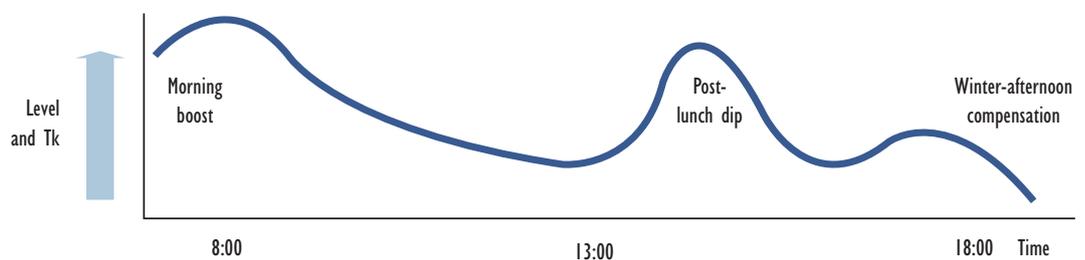
Milena Simeonova is a member of the Healthcare Facilities Committee of the Illuminating Engineering Society of North America (IESNA) and the President and Founder of her own lighting design firm in New York that specialises in the application of healthy lighting. She has worked on a variety of commercial, urban, institutional, religious and healthcare projects. Ms Simeonova has lectured widely and has written numerous articles on healthy lighting and light-emitting diode application. She filed a provisional patent for the circadian receptor and will develop a circadian prototype with a grant from the National Institutes of Health (NIH). She has numerous lighting and health industry credentials, and is actively involved in the implementation of healthy lighting. Ms Simeonova has a Master's degree in Architecture and an MSc in Lighting from the Lighting Research Center at Rensselaer Polytechnic Institute, New York.

1. M Rea, "Light Much More Than Vision", *Proceedings of the EPRI/LRO 5th International Light Research Symposium, 2002*.
2. M Simeonova, "Let There Be Healthy Lighting!", *Lighting Design & Application, (5) 2003, pp. 76-79*.
3. Van Den Beld Gerit, "What is Healthy Lighting at the Work Place?", *Proceedings of the CIE 25th Session, 2003, pp. D6-14-D6-17*.
4. C C Sullivan, "In Search of Ornament", *Architecture, 2003, p. 9*.
5. P Boyce, "Lighting and the Perception of Spaces and Objects", *Human Factors in Lighting, 2003, pp.220-221*.
6. R S Ulrich, "View Through a Window May Influence Recovery from Surgery", *Science, 1984, p. 224*.

Table 1: Lighting Parameters for the Visual and the Circadian Systems

Lighting Characteristics	Application Vision	Circadian Day Shift Work	Circadian Night Shift Work
Quantity	low (300–500 lux on task and ~100 lux at eye)	high (~1,000 lux at eye)	high (~1,000 lux at eye)
Spectrum	photopic (peak sensitivity 555nm)	short wavelength (peak sensitivity 420–480nm)	short wavelength (peak sensitivity 420–480nm)
Spatial distribution	distribution important (task luminance, contrast and size determine visibility)	independent of distribution (illuminance at eye)	independent of distribution (illuminance at eye)
Timing	any time	subjective morning	periodically throughout the shift
Duration	very short (less than one second)	long (1–2 hours)	short (15 minute) pulses

Figure 1: Conceptual Lighting Algorithm for Day Shift Work



### Day and Night

During the day there is light and there is shadow. The light is external, moves around, touches and awakens things. At night, shadows overpower light and mysterious self-luminous contained sources appear. Things are quiet, meditative and confined.

### Spatial Orientation

Outdoor spatial orientation is clear. The position of the sun as a light source anchors the composition of illuminated and non-illuminated areas. Viewing points may change but the logical pattern of light and shadows remains the same. Indoor lighting should reflect the passage of time and preserve spatial orientation.

### Genius Loci

Genius loci is the peculiar character of a place.<sup>7</sup> Lighting is endemic to the region and the particular setting. The character of outdoor lighting should be carried inside and felt in the building. If the ethnicity of the patient population differs from the regional characteristics, then ethnic objects, forms and colours can provide familiarity and comfort. Still-lighting should reflect the regional characteristics.

### Order

Nature comprises inseparable elements or

singularities that interconnect by undeniable laws of nature and form the whole, called 'the order'. Lighting is not to force or to change the nature of things. Lighting should work with singularities following the structure of the whole. Lighting should tell the story of the whole, not of the fragments.

### Change

Ornaments display a continuous metamorphosis with the passage of time and provide uninterrupted meaningful sensory stimulation. Continuous change within a familiar stable framework is healthy. Change also defines the character of the place.

### Colour

Daylight contains all wavelengths of light. Even though atmosphere shifts the morning light to yellow-gold and the late afternoon light to orange-red, people see daylight as white. Daylight also presents a simultaneous mix of cool with warm light. White light and the balanced mix of cool with warm light are perceived as natural. Saturated coloured light without white light can be used for special effects with short exposure. Coloured light small-scale applications will bring excitement and should be used in conjunction with white light. Coloured light will produce unnatural colour-washed shadows.

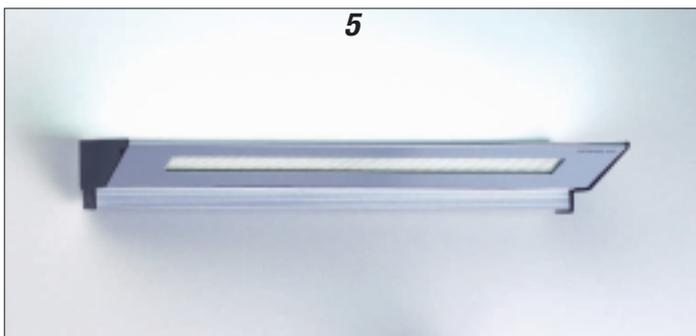
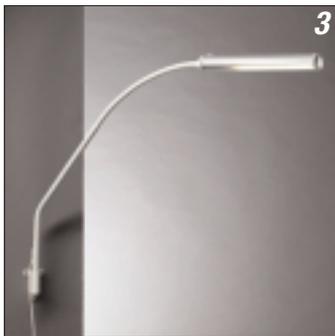
7. M Millet, *Light Revealing Architecture*, John Wiley & Sons: 1996, p. 6.



## HIGHLY FUNCTIONAL LIGHTS FOR HOSPITALS AND CLINICS, GERIATRIC AND NURSING HOMES

Whether you need a compact examination light, bedside or over-bed lighting fixtures, luminaries for creating a cosy general light atmosphere or simply a functional illuminated magnifier for the lab:

**We supply a wide range of light solutions for many medical applications!**



- 1 Compact but powerful for examination
- 2 Safe at the bed: 12V-reading light
- 3 Cool: PL-Bed light
- 4 "Full spectrum": Close to natural daylight
- 5 Two-in-one: General + reading light

For further information please contact:

SIS-Licht  
Gebr. Lang GmbH & Co. KG  
P.O.Box 1464  
97404 Schweinfurt/ Germany

Tel. + 49 9721/6 59 74-3  
Fax + 49 9721/6 59 74-44  
E-mail: welcome@sislicht.de  
Internet: www.sislicht.de

## Healthy Lighting

### Shadows

Shadows are quiet. Subdued light enriches our experience of discovering the space through exploration. Light awakens the space and initiates the communication between planes at different depths. Depth can vary from two opposite walls, to a shallower texture or ornamentation applied at the wall. Planes communicate through projections of intricate patterns and reflections of light that change with the passage of time.

### Continuity

We know to protect the elderly from abrupt changes in light levels by creating transition zones. In a similar way, there should be a gradual transition from one emotion to another, from one setting to another. New settings should present hints of familiarity to help with the transition.

### Controls

Emotional conditions influence perception. An imbalance between the sympathetic and the parasympathetic systems could result in misinterpretation of perceptual cues and ineffectiveness of the lighting system. Pre-conditioning for emotional health may require stimulation of the peripheral visual field to balance with an overactive central field.<sup>8</sup> In general, elderly patients also will require adjustment in lighting conditions to compensate for changes in their visual and circadian systems. In addition, different patient groups will have particular medical needs. Fine-tuned lighting controls are an integral part of the healthy lighting system.

### Conclusion

In conclusion, hospitals are in urgent need of implementing healthy lighting. The presumption that lighting only for the visual and the circadian systems will result in healthy environments is incorrect. The perceptual system and the interpretation of the physical world most definitely influence the wellbeing of individuals. Perceptual cues also support the function of the visual and the circadian systems. Only the healthy interaction between the visual, the circadian and the perceptual systems will result in healthy environments.

Futurist writer Arthur C Clarke identified that "this may be the period where the accelerating pace of change truly exceeds society's ability to comprehend its significance." It is the author's hope that the public understanding of this pioneering concept is increasing. ■

8. R Fox, "Confessions of an Optometric Innovator", Journal of Optometric Phototherapy, 2 (2002), pp. 20-21.