A 24-Hour Lighting Scheme for Older Adults

The proposals herein will not only provide our elderly with good lighting for performing visual tasks, but will also promote the right circadian stimulation at the right time

BY MARIANA G. FIGUEIRO

The lighting community is well aware of how lighting can overcome some of the consequences of the changes that occur to our aging eyes. The Lighting for the Aging and Partially Sighted Committee is one of the most active committees in the IES and has put forward many recommendations to improve mainly the visual environment for older adults. However, light reaching the retina not only allows us to see[1], but it also impacts our health and well-being. Light reaching the retina synchronizes our circadian rhythms to the 24-hour solar day[2] and affects the body's perceptual system, enabling us to orient ourselves to the spatial environment and maintain postural control and stability[3].

As we grow older, less light reaches the retina at the back of the eye, where light signals are processed, thus older adults need more light to maintain good visual, perceptual and biological responses. It is estimated that for the same amount of available light, a 60-year-old receives only about 30 to 40 percent as much light at the retina as a 20-year-old.

Recent research clearly indicates that a lack of light reaching the retina can have other biological effects on older adults. This reduced retinal light exposure can have an even more dramatic negative effect on persons with Alzheimer's disease and related dementia (ADRD) due to their decline in cognitive processes. And this is an important fact because according to 2012 Alzheimer's Disease Facts and Figures published by the Alzheimer's Association, 5.4 million Americans are living with ADRD. The circadian system, which regulates our sleep/wake cycles, requires more light for stimulation than the visual system, and also exhibits a heightened sensitivity to short-wavelength (blue) light, unlike the visual system, which is most sensitive to middle-wavelength (yellow-green) light.

Typical light levels in institutions are static and are not high enough or tuned to the correct color of light to activate the circadian system of older persons, which may result in circadian disruption. This disruption, in turn, can cause changes in patterns of wakefulness and sleep in older adults and in those with ADRD, resulting in confusion in daily routines, lessening of activity levels and alertness, and alteration in mood often resulting in feelings of depression.

Another public health concern is related to injuries resulting from falls in seniors. The visual and perceptual systems intercept cues from the environment that affect postural control and stability, but age-related changes to these systems result in impaired balance control and thus can lead to increased risk of falls among seniors. Falls risks are even greater in those with ADRD who have disrupted higher cognitive processes, resulting in abnormal gait function and movement, significantly greater balance and limb coordination problems, along with a decrease in postural control[4]. Visual information provides a spatial reference for self-position and location of obstacles within a person's surroundings. However, as we age, visual capabilities decrease, while dependence on visual information for maintenance of postural stability increases due to parallel age-related

changes in the perceptual systems.

ROUND-THE-CLOCK PLAN

Since light impacts more than just our vision, it is important that lighting schemes implemented in senior residences also account for the needs of our non-visual systems. The Lighting Research Center (LRC) at Rensselaer Polytechnic Institute has developed and proposed a 24-hour lighting scheme for older adults that not only provides good lighting for performing their routine visual tasks, similar to what is proposed by the IES Lighting for the Aging and Partially Sighted Committee, but also promotes high circadian stimulation during the day and low circadian stimulation at night, and provides low light levels with perceptual cues for nighttime navigation [5].

In addition to benefiting healthy older adults, this lighting scheme can also benefit older adults with ADRD. Behavioral symptoms such as disturbed sleep-wake patterns, nocturnal wandering, agitation and physical or verbal abuse are among the most prevalent reasons why individuals with ADRD transition to more controlled environments. Falls and related injuries are also common in this population and are associated with increased functional impairment, disability, mortality and placement in more controlled environments. Therefore, a lighting scheme that can help overcome some of the sleep, balance and visual issues associated with the disease has the potential to improve the quality of life of persons with ADRD.

Daytime Lighting Scheme. In humans, who have circadian clocks that run, on average, with a period slightly greater than 24 hours, morning light is important to daily reset the clock and, thus maintain its entrainment to the 24-hour solar day. Therefore, for the morning hours, the author (2008) proposed that high circadian stimulation be provided at the cornea via 1,000 lux or more from a circadian-effective white light source for at least two hours after waking. If longer exposures of light are planned, light levels may be reduced to no less than 600 lux at the cornea from the same circadian-effective white light source. But remember, the effect of light on entraining the circadian system will be less in the middle of the day than it will be in the morning, so morning light is preferred.

It is possible to theoretically compare a variety of practical light sources in terms of their ability to provide a criterion response by the circadian system (50 percent nocturnal melatonin suppression) for a fixed, small pupil size (2.3 mm diameter), as shown in **Table 1**. Since commercially available light meters are always calibrated in terms of the photopic luminous-efficiency function, the levels of photopic illuminance needed at the eye are used as the measure of the amount of light needed to reach the criterion response. It is worth noting that under natural viewing conditions, pupil size can be larger than 2.3 mm in diameter, so a lower level of illuminance would be needed to reach this criterion level of melatonin suppression. Generally, for light sources providing the same photopic light level, the greater the proportion of short-wavelength radiation from the source (i.e., the more bluish-white the source is), the more ef-

Light Source	Illuminance (lux)
2700 K compact fluorescent (Greenlite15WELS-M)	1220
2856 K incandescent A lamp	820
3350 K linear fluorescent (GE F32T8 SP35)	1180
4100 K linear fluorescent (GE F32T8 SP41)	1070
5200 K LED phosphor white (Luxeon Star)	430
6220 K linear fluorescent (Philips Colortone 75)	550
8000 K fluorescent (OSRAM Sylvania Lumilux Skywhite)	610
Blue LED (Luxeon Rebel, max = 470 nm)	50
Daylight (CIE D65)	525

Table 1: Photopic illuminance to achieve 50% melatonin suppression. Several practical light sources with the required photopic illuminance (lux, or lm/m^2) levels at the eye, having a fixed pupil diameter of 2.3 mm, for 50% nocturnal melatonin suppression after one hour exposure (adapted from [7]). Although the absolute numbers will vary depending on pupil area, duration of exposure, exact spectral power distribution of the light source, distance from the source, the numbers in Table 1 can be used to determine the relative effectiveness of these different light sources as it may impact acute melatonin suppression, one marker of the biological clock. Whether or not these values are the same for estimating phase shifting of the timing of the biological clock by these light sources is still not established [8].

fective it will be for stimulating the human circadian system. It should also be noted that the relationship between melatonin suppression and consolidation of rest/activity rhythms remains unclear.

Although there is no compelling reason to assume that acute melatonin suppression and phase shifting of the timing of the biological clock respond differently to a light stimulus, it is important to keep in mind that the calculations presented in Table 1 are based on studies where only acute melatonin suppression was measured. Further research should be conducted to determine minimum light levels needed to impact the circadian systems of those with ADRD and to verify how the estimations presented in Table 1 affect rest/activity patterns in those with ADRD. In addition, it is not known how light levels can be reduced with increased duration of exposure during the day. It is also not known how long it takes for the circadian system in those with ADRD to respond to the light treatment. It has been suggested that the effect of light exposure on sleep in those with ADRD is only measurable after six months of treatment, possibly because these patients are slower to respond to the stimulus[6].

Daylight from windows and clerestories is a circadian-effective light source, but, it should not be assumed that there will always be enough circadian stimulation from daylight in architectural spaces[9]. Daylight levels in the room drop quickly as the distance from the window increases; 3 to 4 meters away from a window, daylight levels are quite low, even on a sunny day. It should be noted that if sunlight from the window penetrates the room, discomfort from glare will cause occupants to draw blinds or shades, eliminating daylight entirely from the space.

If energy consumption is a constraint, the architect or specifier can either select specific spaces to implement the proposed lighting scheme or follow a scheme similar to the one used in the experiments by the author, et al.[10,11] by providing another layer of 470-nm light in the morning. Portable luminaires providing diffuse light from 470-nm light emitting diodes can be placed on dining tables, around television screens, or attached to wheelchairs. It is not known, however, how successful compliance with these light delivery methods will be and how acceptable this kind of light source will be to users. More importantly, the light stimulus needs to reach the back of the eye to be effective, so the farther away the person is from the source the lower its effectiveness for the circadian system. Recently, we showed that self-luminous displays used close to the eye, such as tablets used at full brightness mode, deliver light that can slightly stimulate the circadian system after a two-hour exposure. Maybe in the near future, older adults will get their circadian effective light therapy while playing "Angry Birds" on their tablets! Regardless, now is the time to start developing and implementing creative ways to deliver circadian effective light to older adults and those with ADRD.

Good visual conditions for waking hours can be provided by lighting that is high on the task, glare-free with no direct or reflected view of the light source, with softer

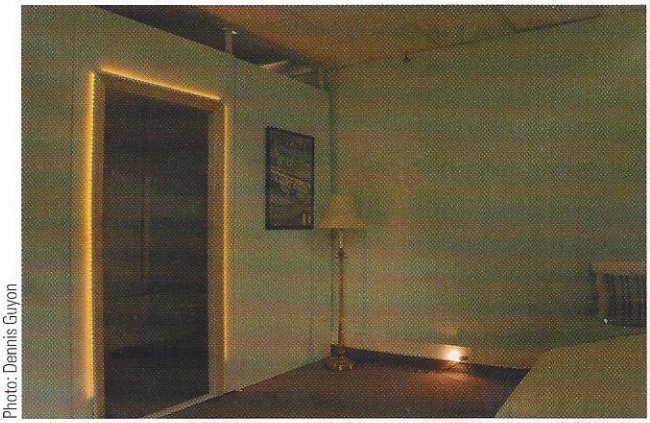

Photo: Dennis Guyon

Figure 1: Novel nightlighting system developed and tested by the Lighting Research Center.

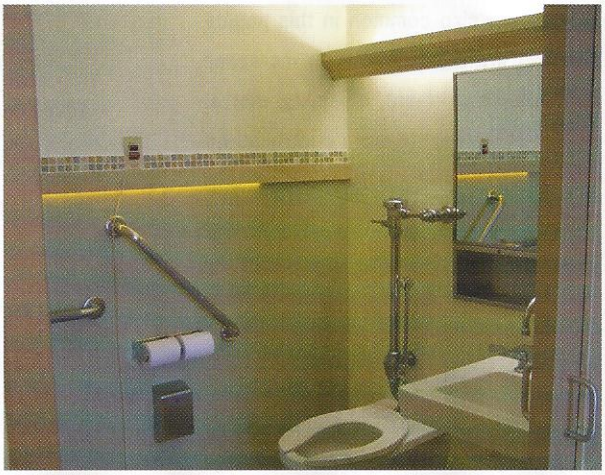

Photo: Patricia Rizzo

Figure 2: Bathroom lighting at Hebrew Home using some of the concepts proposed by the LRC (Lighting Design: Patricia Rizzo).

shadows throughout the space, and that provides balanced illuminance levels and good color rendering characteristics[12].

Evening Lighting Scheme. No more than 60 lux at the cornea of a more circadian-ineffective white light source [e.g., 2,700-3,000K light source] is recommended for general lighting in the evening hours. Although it is expected that this proposed lighting solution will help healthy older adults sleep better, the exact amount of light needed to impact the circadian systems of those with ADRD is not known because they may have a reduced response to the light stimulus.

For maintaining good visual conditions for critical visual task during the evening, consider using task lamps illuminating these critical tasks. If using self-luminous displays, such as tablets or computer screens, consider reducing its brightness or using white font on black background. Avoid using self-luminous devices for many hours prior to sleeping.

Nighttime Lighting Scheme. Just as important, the proposed 24-hour lighting scheme should provide nightlights that reduce the risk of falls and help maintain sleep. The author proposed the use of nightlights that provide visual information about the local environment (5 lux at the cornea)[5], as well as perceptual information that enables the residents to orient[13-15]. The proposed nightlights accent the rectilinear architectural features in the room as well as accentuate horizontal pathways to the bathroom. The use of motion sensors with dim nightlights eliminates the need to find switches in the dark and helps residents remain asleep when caregivers enter the room. The use of low light levels allows older adults to navigate

Building a Model for Dementia Care

By Christopher Brown

After my mother died from Alzheimer's, I became involved with Abe's Garden, an organization that is establishing an Alzheimer's and Memory Care Center of Excellence in Nashville, TN. Abe's Garden is developing a best practice model for dementia care through a committed collaboration with Vanderbilt Center for Quality Aging.

Since my earliest days of involvement, I began envisioning another multi-faceted, mutually beneficial collaboration—Abe's Garden and my friends in the lighting industry working together to address one of our nation's most critical healthcare issues. As a result, two colleagues have catapulted the initiative forward:

- Scott Muse of Hubbell Lighting has committed significant technical and financial support, and
- Mariana Figueiro of the Lighting Research Center has devoted a semester of her Masters in Lighting class to the research that led to the publication of her paper "Light Therapy and Alzheimer's Disease and Related Dementia: Past, Present, and Future" in the *Journal of Alzheimer's Disease* (available in full at *http://www.j-alz.com/issues/33/vol33-4.html*).

Now, Scott Muse and I are asking you, our colleagues in the lighting industry, for financial support to build Abe's Garden and support Alzheimer's research throughout the nation. Mariana's paper and the adjacent article have the potential to provide immense value to lighting product designers, manufacturers, lighting specifiers and architects.

If you find value in current and future research regarding the impact of lighting on individuals with Alzheimer's disease and related dementias, or if you have experienced the devastating impact of these diseases, please join us in contributing to the Lighting Industry Challenge at *www.abesgarden.org/lighting*; to Abe's Garden, Lighting Industry Challenge, 618 Church Street, Suite 220, Nashville TN 37219; or to the Alzheimer's 501(c)(3) non-profit organization of your choice.

Together we can demonstrate how lighting, and its champions, can improve the lives of individuals impacted by Alzheimer's and related dementias. Thank you, in advance.

Christopher Brown is chief executive officer of Wiedenbach-Brown Co., Inc..

through the space safely without disrupting their sleep. The use of low levels (less than 5 lux at the cornea) of amber lights or 2,700K light sources will not impact the circadian system (unlike short-wavelength, blue light) and avoids the risk of providing an alerting stimulus, as has been shown with red light[16]. This proposed novel night lighting system shown in **Figure 1** needs to be tested in persons with ADRD and installed in the field, but it has promising features to help reduce the risk of falls in those with ADRD.

A PLEDGE TO THE LIGHTING COMMUNITY

The lighting principles described here are supported by scientific results but we need the lighting community to embrace them. What I mean by embracing is that we need champions that will facilitate the implementation of these simple lighting solutions in residences of older adults. My LRC colleague Patricia Rizzo recently implemented some of these concepts in the Hebrew Home in Hudson, NY (**Figures 2-4**). The residents and the administrators are raving about her lighting design. The leadership of Abe's Garden, an Alzheimer's Center of Excellence in development in Nashville, TN, is establishing a national model of residential and day care programs for those suffering from ADRD, and will be implementing some of these principles on their campus (see sidebar). It can be done! Design a space, specify a luminaire, create a lighting product, implement a solution. Let's start implementing simple, yet effective lighting solutions to improve the quality of life of older adults, including those with ADRD. Let's just do it! ■

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Photo: Patricia Rizzo

Figure 3: Dining area lighting at Hebrew Home (Lighting Design: Patricia Rizzo).

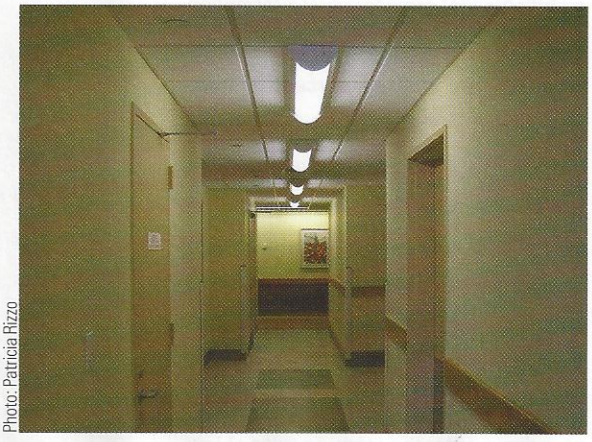

Photo: Patricia Rizzo

Figure 4: Corridor lighting at Hebrew Home (Lighting Design: Patricia Rizzo).