24-HR LIGHTING SCHEME FOR OLDER ADULTS

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As we grow older, changes to the aging eye reduce the amount of light reaching the retina and therefore more light is needed for our visual and non-visual functions. The Lighting Research Center at Rensselaer Polytechnic Institute developed a 24-hr lighting scheme for older adults that compensates for the changes in the aging eye and that can positively impact the aging visual, circadian and perceptual systems. As we grow older, less light reaches the back of the eye, making it more difficult to perform daily tasks. Moreover, since light reaching the back of the eye is also important in order to maintain our body rhythms synchronized with the 24-hr solar day, it is important that the lighting scheme takes into account the needs of our non-visual systems. Finally, lighting cues can increase postural stability and reduce falls risk in older adults. The Lighting Research Center's proposed lighting scheme not only provides older adults with good lighting for performing their routine visual tasks, but also promotes high circadian stimulation lighting during the day and low circadian stimulation at night. It also provides low light level lighting with perceptual cues for nighttime navigation. A series of research projects are underway to test the effectiveness of this lighting scheme. The 24-hr lighting scheme proposed here should be adopted by architects, lighting specifiers and engineers to improve the quality of sleep and quality of life of older adults living at home, in assisted living facilities, or in more controlled senior environments.

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Introduction

Light reaching the retina allows us to see (1), but its impact on health and wellbeing does not end there. Light reaching the retina also synchronizes our circadian rhythms to the 24-hr solar day (2), and lighting also affects the body's perceptual system, enabling us to orient ourselves to the spatial environment and maintain postural control and stability (3).

However, as we grow older, less light reaches the retina at the back of the eye where the light signals are processed, so older adults need more light to maintain good visual, perceptual and biological responses. Older eyes also have reduced pupil size and thicker lenses, resulting in less light reaching the retina and more light scattered in the eye. It is estimated that for the same amount of available light, a 60-year-old receives only about 30-40 percent as much light at the retina as a 20-year-old. In addition, as age increases, so does the proportion of people in each age group with partial sight. Based on population estimates, the over-65 partially sighted group in the United States could reach nearly 6.9 million people by the year 2015.

In an aging visual system, there is a more limited ability to respond to changes in brightness. This means increased difficulty adapting from one environment to another with great variations in light levels. It may also translate to increased difficulty seeing darker areas within a single environment if some surfaces are much brighter than others.

Changes in the aging eye may also have some effect on the way colors are perceived due to yellowing of the lenses and increased light scatter. Older people tend to lose sensitivity to muted colors and prefer highly saturated colors. It also may be more difficult to discriminate between colors in the blue/purple/brown range, due to a thicker lens filtering out some wavelengths of light.

Due to both age and visual impairment, changes in the visual system interfere with a person's ability to achieve or maintain independence. Older adults face many visually dependent tasks including orientation, mobility, reading, writing, personal care, food preparation, and recreational activities. Although different lighting solutions may be required for each situation, effective and good quality lighting solutions in any situation will improve the visual environment and enable more comfortable, effective, and less frustrating performance of visual tasks.

Beyond Vision

In addition to lighting's effect on visual ability, recent research clearly indicates that a lack of light reaching the retina can have other biological effects on older adults. Light is the main synchronizer of our body's biological rhythms that repeat approximately every 24 hours, called circadian rhythms. Lack of a robust light/dark pattern disrupts these natural sequences within the body. The circadian system, however, requires more light for stimulation than the visual system, and also exhibits a heightened sensitivity to blue light, unlike the visual system, which is most sensitive to yellow-green light. Typical light levels in institutions 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, confusion in daily routines, lessening of activity levels and alertness, and alteration in mood often resulting in feelings of depression.

Impaired sleep is a common problem among older persons and is associated with reduced daytime function, greater risk of mood disorders, reduced quality of life, and increased health care costs. A recent national probability survey estimated that 48 percent of persons aged 60 and older have difficulty falling asleep and/or maintaining sleep, and over 20 percent report severe insomnia. Individuals with impaired sleep report diminished quality of life in a broad range of aspects of social and physical function, mental health, and vitality. Older adults who suffer from impaired sleep often report daytime symptoms associated with sleepiness, including an inability to concentrate, forgetfulness, and increases in falls and injuries. Poor sleep is a major risk factor for developing mood disorders, such as depression and anxiety, with 20 percent of individuals with insomnia having concomitant depression. Also, multiple studies have shown that impaired sleep negatively affects the immune system, leading to increased illness and subsequent physician visits and treatments. At least $14 billion per year is spent directly on insomnia care, with the overall costs of sleep disorders being considerably higher.

Circadian rhythm disturbances parallel the increased prevalence of sleep disorders with increased age and cognitive impairment. Therefore, architectural environments that provide residents with a robust light/dark pattern designed to specifically promote synchronization of circadian rhythms to a 24-hr day constitute a physiological method of treating many sleep disorders in older persons, including those with cognitive impairment.

A Balanced Life

Injuries resulting from falls in seniors have long been a public health concern. 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 increase risk of falls among seniors.

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 seems to increase due to parallel age-related changes in the perceptual systems. Lighting that gives horizontal and vertical cues by reinforcing architectural features in the space (e.g., doorframes) can be used to strengthen visual information for the perceptual system and reduce risks for falls, especially during nighttime, when light levels are low.

In considering the design of healthy and supportive environments for older adults, architects must keep in mind not only the visual, perceptual, and biological needs of this population, but also the needs of other family members and caregivers, as well as energy-efficiency and environmental sustainability concerns.

Current and Future Work

The Lighting Research Center (LRC), through the American Institute of Architects (AIA) Research Grant, developed an integrated, 24-hr lighting design strategy for older adults, which takes into account the needs of the aging visual, circadian and perceptual systems (4). As a follow-up from this original grant, the LRC has been able to secure funding to continue testing the effectiveness of this proposed lighting scheme. Figures 1 and 2 illustrate the concepts.

One project underway is a direct extension of work performed under the AIA Research Grant and is funded by the National Center for Complementary and Alternative Medicine (NIH/NCCAM) and conducted in conjunction with the University of North Carolina. This LRC study examines the effectiveness of a high correlated color temperature (CCT) lamp on sleep efficiency during the daytime. CCT is a specification of the apparent color of a light source. The CCT rating for a lamp is a general indication of the warmth or coolness of its appearance. The higher the correlated color temperature, the cooler, or more blue, the color appearance. In brief, 21 Alzheimer's disease patients will be exposed to 1-hr of blue light in the morning delivered by a light box (Philips/Apollo Health GoLite light boxes), and then exposed to a high CCT light source (17,000 K) during the daytime hours delivered by adding table and floor lamps to their environment. A series of outcome measures looking at subjects' rest/activity rhythms, sleep quantity and quality, and caregiver burden will be evaluated.

Figure 1: Example of high CCT table lamp to be used during the daytime hours. At night, a second lamp type, a low CCT one, can be used in the same table lamp.

Figure 2: Picture shows the nightlights concepts. The use of horizontal/vertical light cues around the bathroom doorframe can be used to provide not only low level illumination, but also perceptual cues to help increase postural control and stability.

Another current LRC study, sponsored by the National Institutes of Health - National Institute of Nursing Research, is designed to investigate the effectiveness of horizontal and vertical light perceptual cues on falls risks. Researchers will examine, in a lab setting, the impact of providing horizontal/vertical information on postural stability and control. Balance data will be collected for 48 subjects (24 fallers and 24 non-fallers) under various lighting scenarios (ambient lights, night lights and horizontal/vertical lights). Results for both this study and the Alzheimer's study are expected to be available in 2012.
In order to distribute information about the 24-hr lighting design strategy for older adults, three technical papers have been published in peer-reviewed journals (4-6) and three magazine articles have been published in international trade magazines (7-9). The goal is to detail the proposed 24-hr lighting scheme in architectural terms, without losing sight of the research foundation upon which it was developed.

Looking ahead, the LRC plans to continue this area of research and is pursuing a project sponsored by the National Institute on Aging to develop and test a new light measuring device that would help quantify light exposure and activity patterns in Alzheimer's patients while they are being exposed to the new 24-hr lighting scheme. This project would again test whether the high CCT lighting increases sleep efficiency and improves quality of life, but the project would involve a larger population of Alzheimer's disease patients and their caregivers.

Poor sleep quality and falls are two major problems experienced by a majority of senior health care facility residents. Innovative, scientifically supported approaches to lighting design can provide solutions to improve quality of life for seniors. The 24-hr lighting scheme can make a positive difference in the lives of older adults, reduce burden on caregivers, reduce operating costs in senior housing, and possibly keep older adults at home longer, reducing the need to move to a more controlled environment. The proposed 24-hr lighting solution is also sustainable in the sense that it uses energy-efficient light sources and incorporates lighting controls to keep lights on and off at appropriate times. Perhaps most importantly, the LRC's 24-hr lighting solution provides a practical, efficient and effective means to implement the latest research results into design in order to improve quality of life for a large and ever-growing growing population – and it can start today.

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