SAGE
Society for the Advancement of Gerontological Environments

The Cottage at Cypress Cove: Circadian Lighting Design Approach

Special Supplement to the
2018 SAGE Post-Occupancy Evaluation White Paper

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2018 SAGE Post-Occupancy Evaluation

The **Society for the Advancement of Gerontological Environments** (SAGE) has been conducting post-occupancy evaluations for more than a decade. In 2018, a post-occupancy evaluation was conducted at the Cottage at Cypress Cove in Fort Myers, Florida. A particular focus of the post-occupancy evaluation was the circadian lighting employed in the common areas and its impact on residents and staff.

CLICK HERE for access to the 2018 SAGE Post-Occupancy Evaluation White Paper.

CLICK HERE to view a recording of the SAGE webinar, "An Analysis of Design Goals and Outcomes through a SAGE POE: Cypress Cove Memory Care Assisted Living Households." This webinar was presented on November 8, 2018.

CLICK HERE to view a recording of the SAGE webinar, "A Closer Look at the Sensory Environment through a SAGE POE: Cypress Cove Memory Care Assisted Living Households." This webinar was presented on December 6, 2018.

Circadian Background

Circadian rhythms lie at the core of all biological activity and research has shown that maintaining proper circadian rhythmicity is key to maintaining proper health. In fact, the 2017 Nobel Prize in Physiology was awarded to key researchers who were involved in the discovery of how circadian rhythms govern human life. Furthermore, circadian dysfunction has been shown to increase the risk of cancer[1] , metabolic disease[2], cardiovascular disease[3], diabetes[4], obesity[5] and addiction[6]. The central pacemaker that regulates these rhythms lies within the hypothalamus of the brain. Interestingly, this region of the brain receives direct input from the retina implying that this pacemaker is synchronized to the light/dark cycle of the sun. Indeed, decades of research has confirmed that the sun is the leading synchronizer of circadian rhythms. Moreover, a newly discovered non-visual photoreceptor, called Melanopsin, has been shown to be the primary driver for circadian entrainment.

Daylight Spectrum vs Melanopsin Sensitivity Curve

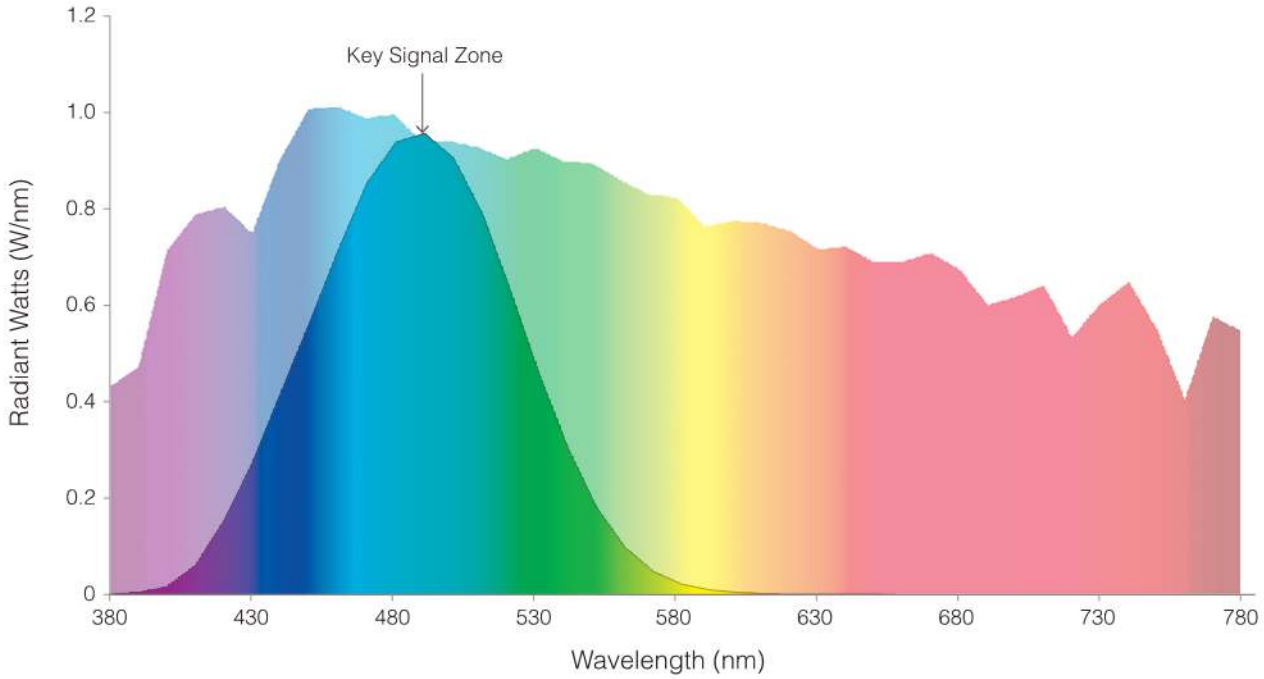


Figure 1: *Comparison of Daylight spectrum (faint rainbow) and sensitivity curve for newly discovered non-visual photoreceptor called melanopsin (bright rainbow).*

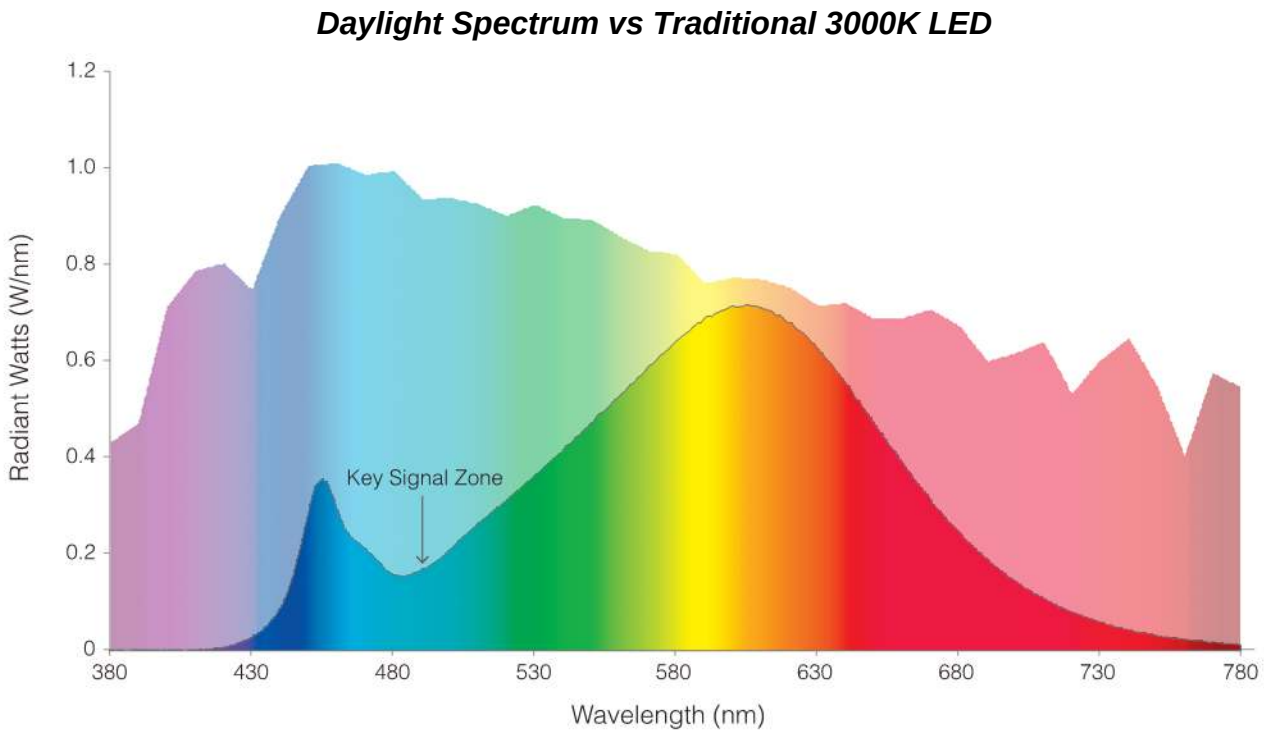


Figure 2: *Comparison of daylight spectrum (faint rainbow) and spectrum of commonly found 3000K LED, with trough in the skyblue region.*

Melanopsin has a peak sensitivity in the "sky blue" region between 485nm and 490nm. This is an important detail because it is this sky-blue region (abundantly found in a blue sky) that is often missing in most electric light sources (see figures 1 and 2). This becomes critically important as we now spend more than 90% of our lives indoors, removed from that critical skyblue signal, under indoor light levels that are too dim to be considered daytime and too bright to be considered night. Exposure to this perpetual biological "twilight" leads to a poor circadian signal and ultimately circadian dysfunction. Simply put - The key to reinforcing a healthy circadian signal is to create brighter days and darker nights. Creating a biologically meaningful light signal can be achieved through modification of light spectrum because our internal clocks are governed by a non-visual photoreceptor. Moreover, the warmness or coolness of white light you see may provide some insight to the biological potency but does not guarantee such.

Circadian Considerations for the Elderly

When designing for the aging population, there are additional physiological factors that need to be considered:

- **Decreased mobility** - Results in less access to daylight and outdoor environments.
- **Yellowing lenses** (**cataracts**) - Exclusively reduces blue light transmission to retina.
- **Decreased visual acuity** - Seniors require more light and increased contrast to perform tasks.
- **Issues with Glare** - Heightened sensitivity and susceptibility to glare overall, with an increased risk specifically from blue enriched light sources.

These additional physiological changes create several challenges as we age, resulting in what seems like a paradox between our visual and circadian system needs. For example, while seniors require more light to perform tasks and also require more blue light to help support their circadian systems and compensate for the lens transmission issues, they are also more susceptible to glare from brighter and bluer light sources.

Typical 3000K LED Spectrum + Melanopsin Sensitivity Curve

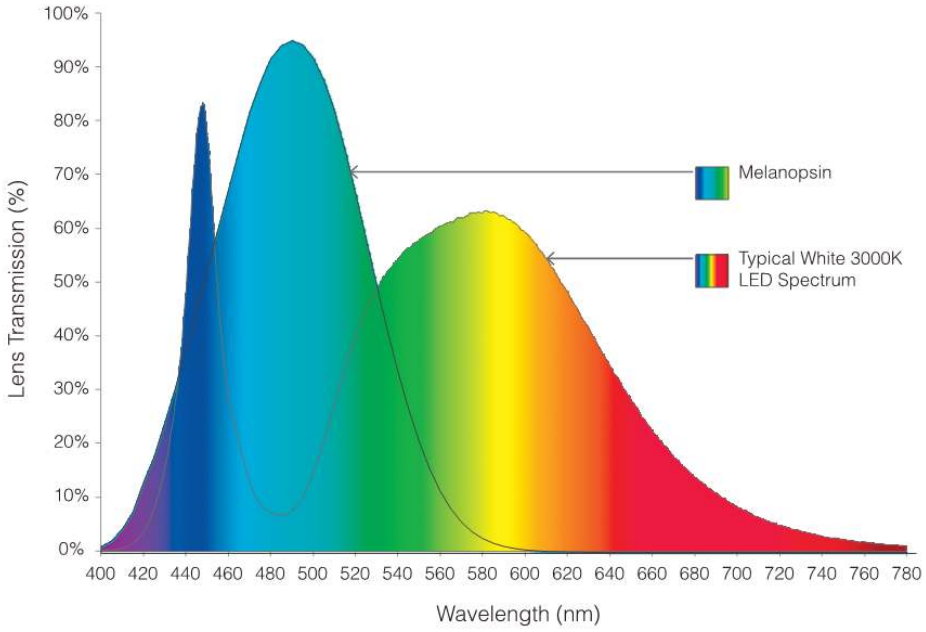
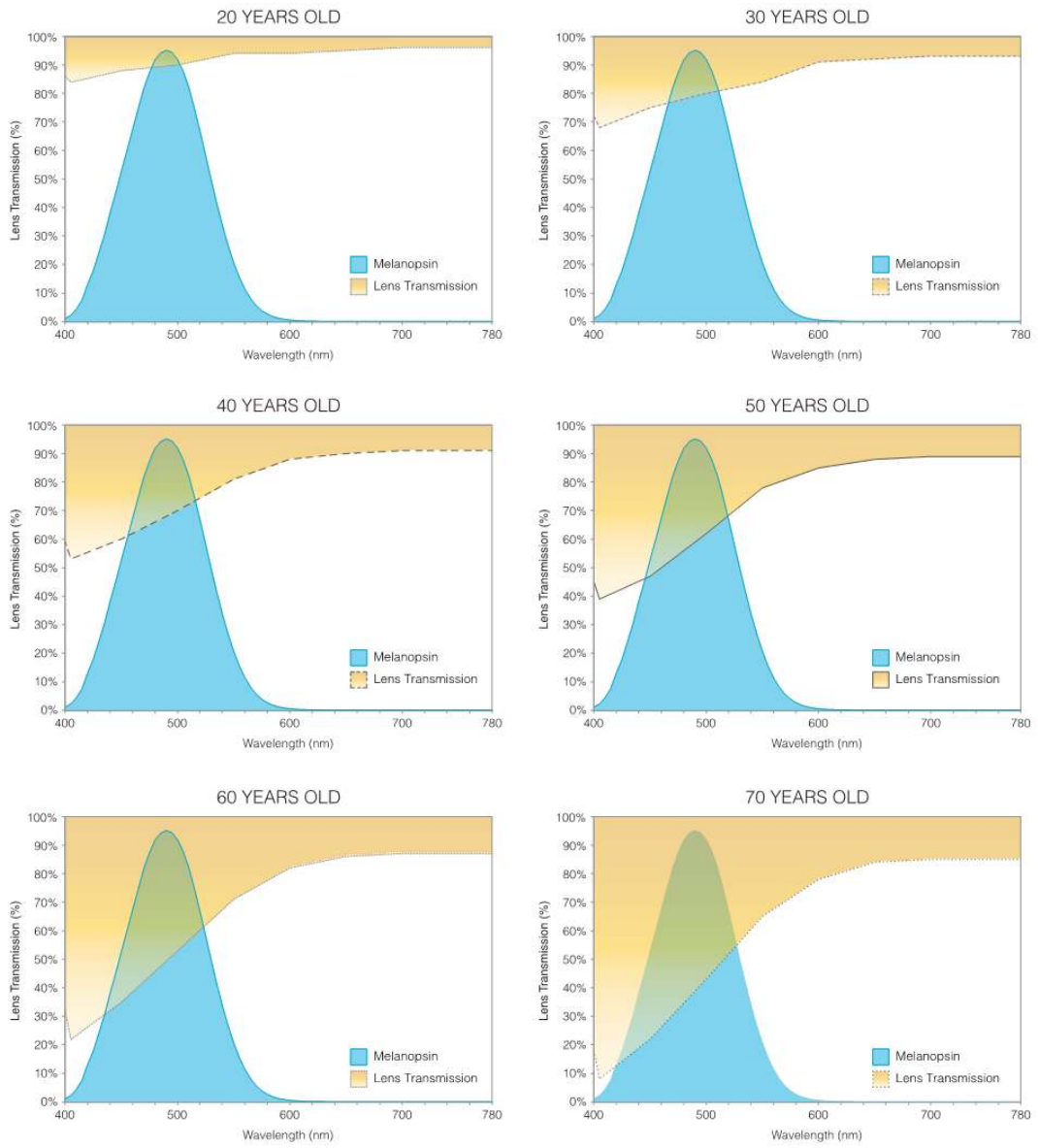


Figure 3a: *Comparison of the spectrum for a typical 3000K white LED as it relates to the melanopsin sensitivity curve. When overlayed, these charts illustrate how traditional white LED sources are missing a key part of the spectrum in the sky blue wavelengths. This shows how traditional LED lighting is not as effective at providing the sky blue signals which are critical to helping send daytime circadian signals to our brains and bodies.*

Effects of Lens Transmission with Age + Melanopsin Sensitivity Curve



melanopsin sensitivity curve. These charts illustrate the impact of reduced lens transmission on the sky blue wavelengths of light that are critical for circadian entrainment. When lens transmission is considered, we see that the much of the sky blue signal that our brains' receive is removed as we get older, due to increased yellowing of the lens. This exacerbates the issue of providing sufficient daytime signals to the elderly and the aging eye. Adapted from Kessel et al. 2010, Journal of Cataract and Refractive Surgery.

Effect of Lens Transmission on Typical White LED Light as We Age

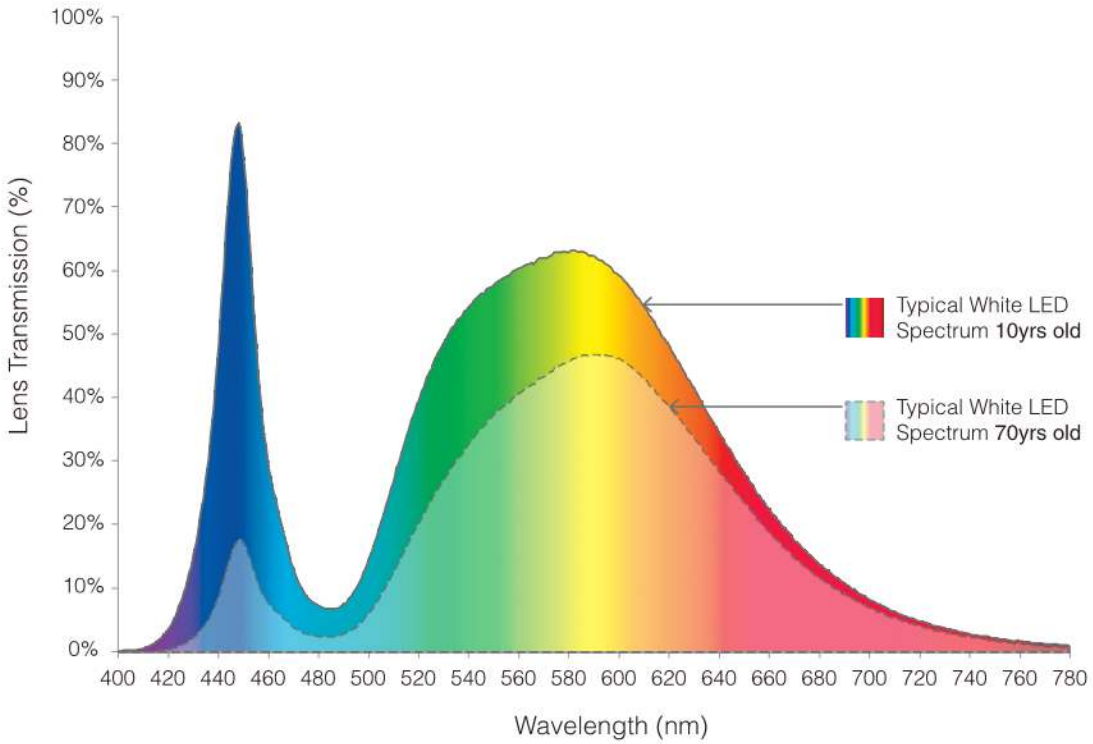


Figure 3c: *Comparison of the effects of lens transmission at various wavelengths as we age. A typical spectrum for commonly found white LEDs is pictured here. The graphs compare how a typical white LED spectrum is affected by the changes to our lens from age 10 (saturated rainbow) to age 70 (faint rainbow). This chart also illustrates the spectrum of a traditional LED light source is poor for providing daytime signals in the sky blue region. Furthermore, when lens transmission is considered, the majority of the blue light is removed from the spectrum, exacerbating the issue a making it even hard to provide sufficient daylight signals to the aging eye.*

Citations

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The conflicting lighting needs between our visual and circadian systems as we age may help explain why elderly are more susceptible to circadian dysfunction. Elderly are often not provided adequate light during the daytime to properly synchronize the circadian clock. Behavioral outcomes of circadian dysfunction amongst the elderly present themselves as increased nighttime wandering and daytime napping, increased agitation and depression as well as higher likelihood of sundowning syndrome, a condition of increased agitation during late afternoon/early evening hours often around the time that sunset occurs. Furthermore, the long-term effects of sleep fragmentation that results from circadian dysfunction leads to increased risk of Alzheimer's disease. In fact, a longitudinal study of a group of 144 people over 3.5 years showed a bright light intervention during the day provided a 73% reduction in cognitive decline compared to the group who did not receive a bright light treatment [7].

Thus, research is showing that it is imperative to provide proper daytime light signals to help reinforce and synchronize our biological clocks. One approach to balance visual and circadian system needs is to utilize indirect lighting strategies and larger light sources when possible.

Recommendations on how to complete this:

Indirect lighting, such as cove lighting, distributes a large amount of light upward, onto the ceiling over a large area, while minimizing glare. When cove lighting is combined with decorative architectural light fixtures, contrast ratios are further decreased, which helps improve visual comfort. Furthermore, full cutoff downlights can provide increased light levels to assist with navigation without providing too much glare.

Common Areas - Lighting Strategy

Overview

The Cottage at Cypress Cove employs circadian lighting in the common spaces, such as the dining room (figure 4), living room (figure 5), kitchen (figure 6), and TV area (figure 7), but not into the bedrooms. This approach gives the residents the freedom to light their private space according to individual preference, while leaving the master dynamic control to the common spaces.

Circadian lighting is employed and connected to an automated control system driven by an astronomical clock. During the daytime hours, a static blue-enriched spectrum is used and in the evening hours a blue-depleted amber light is provided. The lighting control system is hidden away in a server room, where none of the work staff would touch it and potentially adjust the settings.

Circadian lighting is only employed in the cove lighting and the downlights and is not included in the decorative light fixtures. Decorative architectural lighting has not yet embraced circadian lighting. This is probably due to the fact that color changing affects the appearance of these decorative lighting fixtures.

Application

Providing sufficient daytime light signals to seniors is a general challenge as it requires bright and blue enriched light. Indirect lighting approaches such as cove lighting is a great way to provide the intensity required without causing too much glare. The design team used circadian cove up-lighting in the kitchen area, dining area, and living room. The spaces under the cove lights appeared bright and cheerful, without being too glary.

Spectrum

Because melanopsin has a peak sensitivity in the long wavelength blue (sky blue) and the yellowing lenses of the elderly primarily remove short wavelength blue (royal blue), it is imperative that the spectrum of light has a heightened amount of long wavelength blue. However, most circadian solutions do not include energy in this sky-blue region. In fact, most light sources have a trough in the sky-blue region. This is true in the circadian lighting system that was applied at the Cottage at Cypress Cove. To compensate for this deficiency in sky-blue content, the color of the light needs to be much bluer to compensate for a non-ideal spectrum (see figures 4-8).

Dining Room

Main Living Space: This is where circadian lighting makes the most sense.
Application: Cove lighting is IDEAL. Provides a lot of light with minimal glare.
Spectrum: Spectrum could be better by highlighting key "sky signaling" zone.

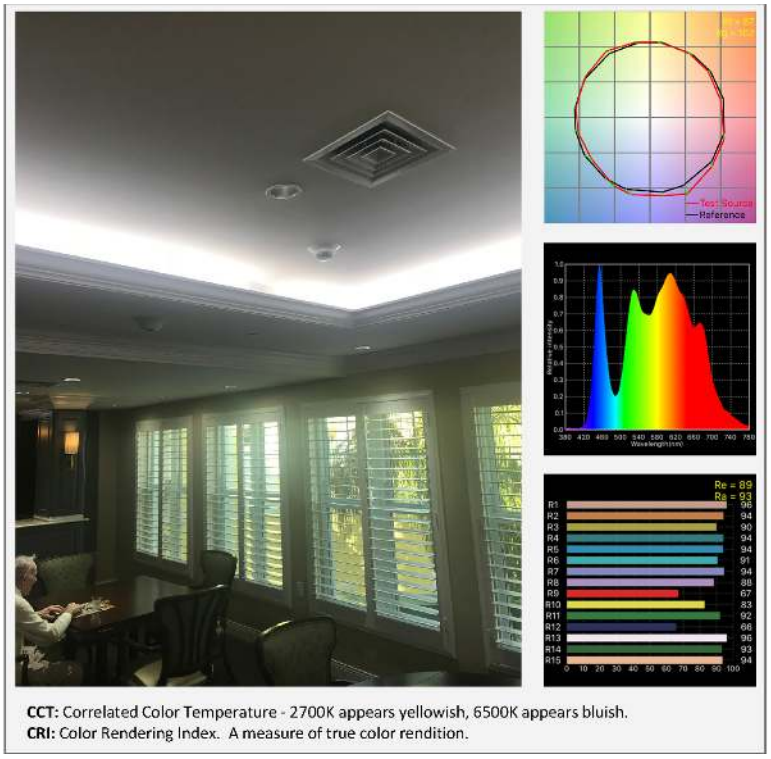


Figure 4: *Dining room during daytime hours, provides a full spectrum with a trough in the Melanopic region.*

Kitchen

Common Area with seating and food service: Lots of traffic into this area.
Application: Great location for circadian lighting. Bright days with blue enriched spectrum and dim amber lights.
Spectrum: Peak spectrum near deep blue with a trough at the sky blue. This results in much bluer appearing light than is necessary, potentially causing more glare. Great application of the technology at the time.

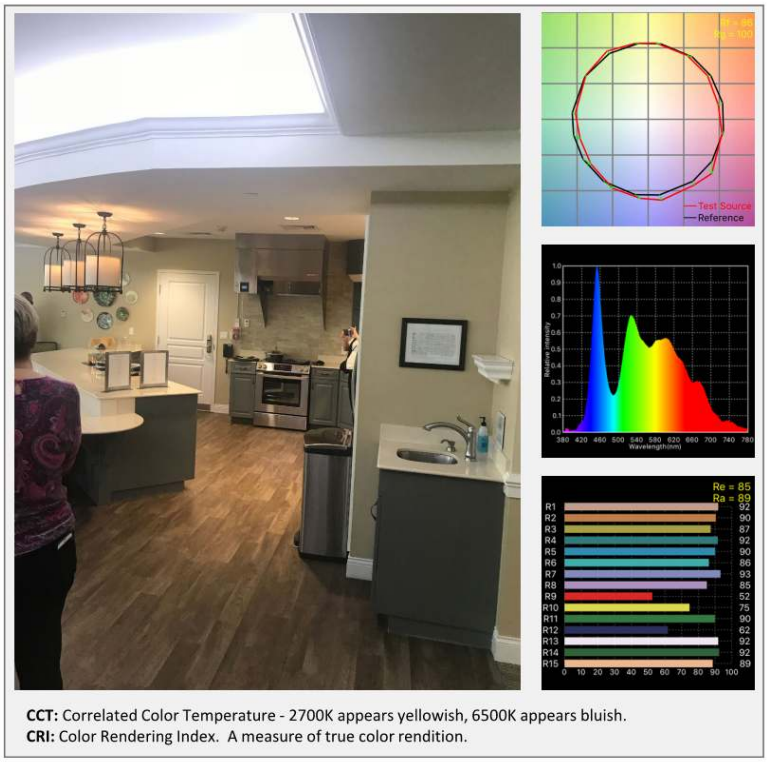


Figure 5: *Kitchen*

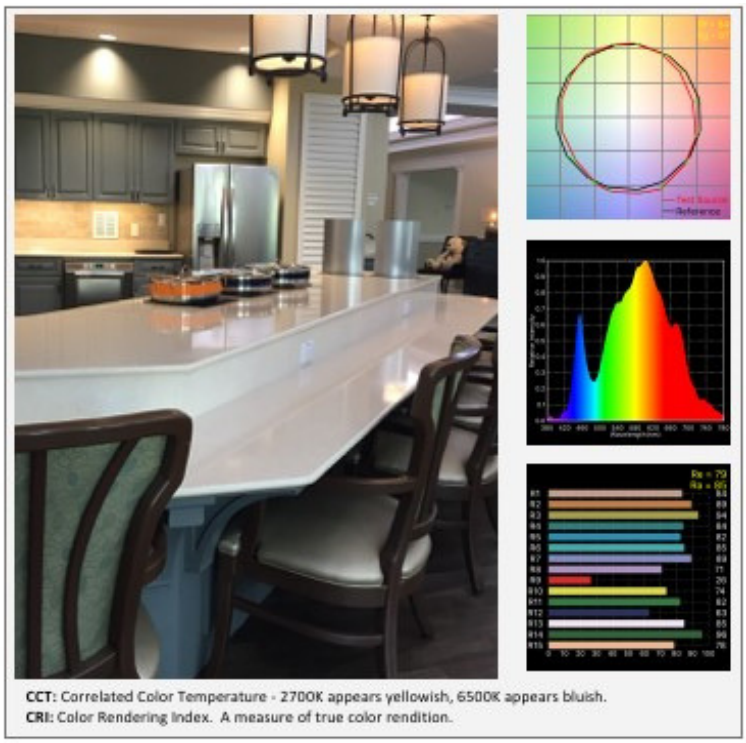


Figure 6: *Kitchen Counter*

Kitchen Counter

Eating area in the kitchen: Seating area and food service.
Application: Although circadian lighting was present, the lighting in this area was dominated by the decorative lights.
Spectrum: Lighting was typical warm white LED spectrum. It could have been in sync with the surrounding circadian lighting.

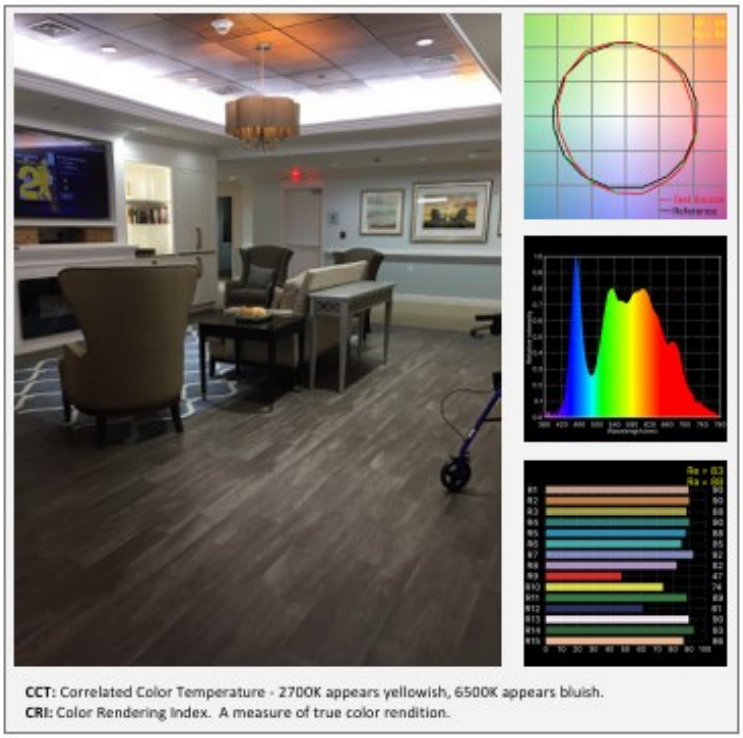


Figure 7: *Back area where residents watch TV.*

Watching TV

Relaxing area in the back: Wood ceilings with comfy couches.
Application: Circadian lighting was used, but daytime colors clashed with the wood ceilings. Cove was shallower than other rooms, creating more glare than in other coves.
Spectrum: Spectrum was changed due to the wood ceilings. This room is not as pleasant as the others.
Recommendation: Choose circadian lighting with white ceilings or static warm white with wood ceilings.

Corridor

Navigation Space: Provide good visibility with good color contrast and a clearly illuminated pathway.
Application: Cove lighting is a great way to provide adequate light levels and uniformity while still maintaining comfort. Wood ceilings in cove are a nice touch to soften the cove even further.
Spectrum: Fluorescent lighting is still commonplace for decorative lighting fixtures. Tunable downlights in the background are probably not necessary for their transient space.

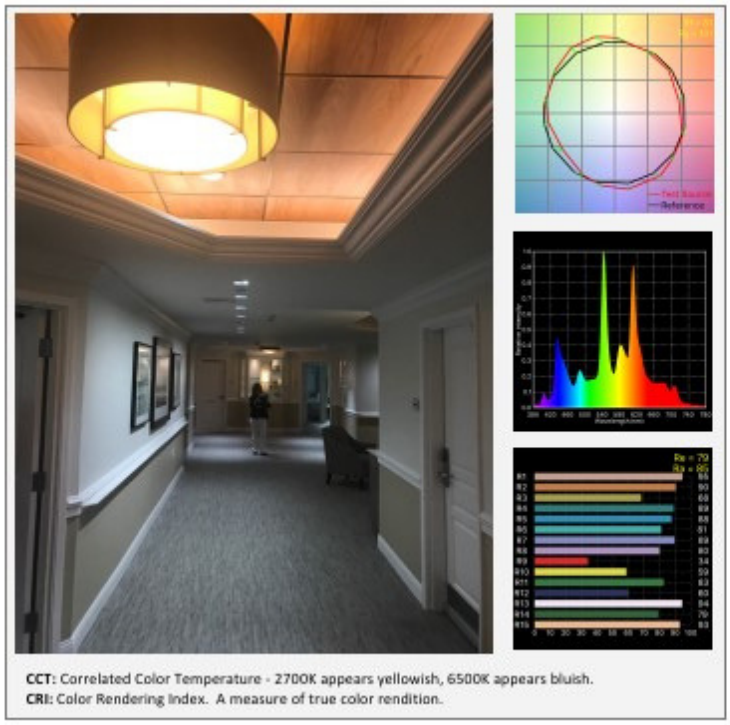


Figure 8: *Corridor to rooms.*

Private Areas - Lighting Strategy

Overview

The design goal in the resident bedrooms was to provide the occupants the freedom to choose the light levels they wanted. Each bedroom has an en-suite bathroom and shower.

Application

The bedrooms are outfitted with cove lighting throughout. The cove lights are equipped with a personal dimmer that allows the occupant to have control of the light levels and determine what is comfortable for them. Nightstands are provided for personal belongings and to allow occupants to have bedside table lamps.

The path to the bathroom is illuminated by an amber navigation light (figure 12). This light remains on throughout the day and night, providing very minimal light during daytime, while providing enough to allow residents to safely get to the toilet in the middle of the night.

Shower and vanity areas are illuminated using recessed downlights that are fairly comfortable.

Spectrum

The resident rooms have windows in the bedroom and bathroom. Ideally, residents would only occupy these spaces at the beginning and end of the day. With that in mind, it makes sense to use a warmer white light that does not provide circadian stimulus in these areas.

The amber navigation light is absent of all blue wavelengths, as its goal is not to render color, but merely light the way to the toilet without disrupting sleep pattern.

The only location where a high circadian lighting approach may make sense is the shower, assuming that residents shower in the beginning of the day. Additional circadian applications could include a cove light above the bed which is timed to provide high circadian light like an alarm clock (e.g. turning on daily from 7 am – 11 am).

Figure 9: *Private resident room.*

Private Resident Room

Sleep Quarters: Residents' private rooms with freedom for individuality.
Application: Residents have freedom to adjust lighting to individual preferences. Warm white cove with dimmer. Reading light over bed.
Spectrum: Soft white 3000K white light with minimal blue frequencies is a good choice for sleeping quarters.

Bathroom Lighting

Main vanity area: Place where residents can get themselves ready for the day.
Application: High color rendering with no harsh shadows and lots of indirect light.
Spectrum: Warm white tones are a good idea here for comfort, but spectrum could use more deep reds for better skin reflections. R9 value should be greater than 50 (this lighting measures 8).

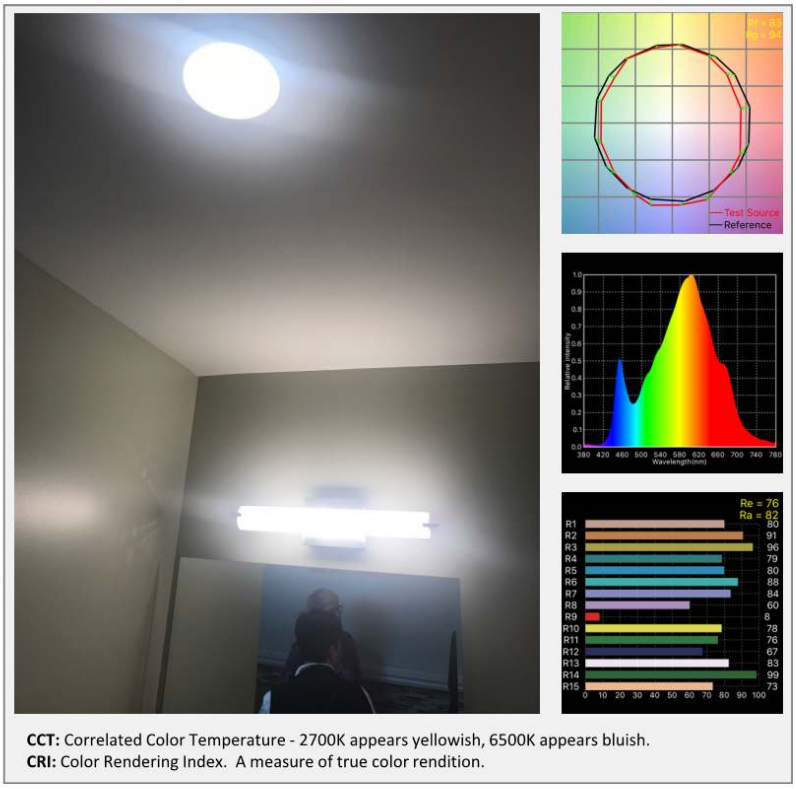


Figure 10: *Bathroom vanity area.*

Shower Light

Safety-critical Space: Good visibility is critical to prevent slips and falls.
Application: Lots of lights with no potential for harsh shadows.
Spectrum: Comfortable warm white light with strong red peak. Good for vanity. Similar spectrum could have been used at vanity. R9=46, is still slightly below recommendation of 50, but close enough.

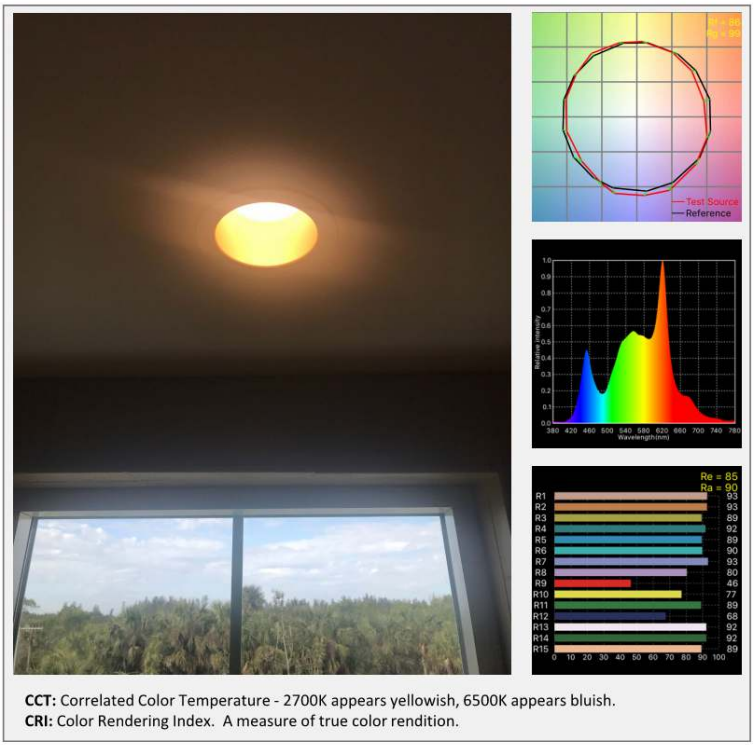


Figure 11: *Bathroom shower light.*

Bathroom nightlight over toilet

Nighttime navigation: Avoid falls from nighttime trips to the restroom.
Application: Always on. Just enough light that is hardly noticeable during the day, but plenty to see by at night.
Spectrum: Amber light is absent of any blue spectrum that might disrupt sleep or circadian rhythms. Great application.

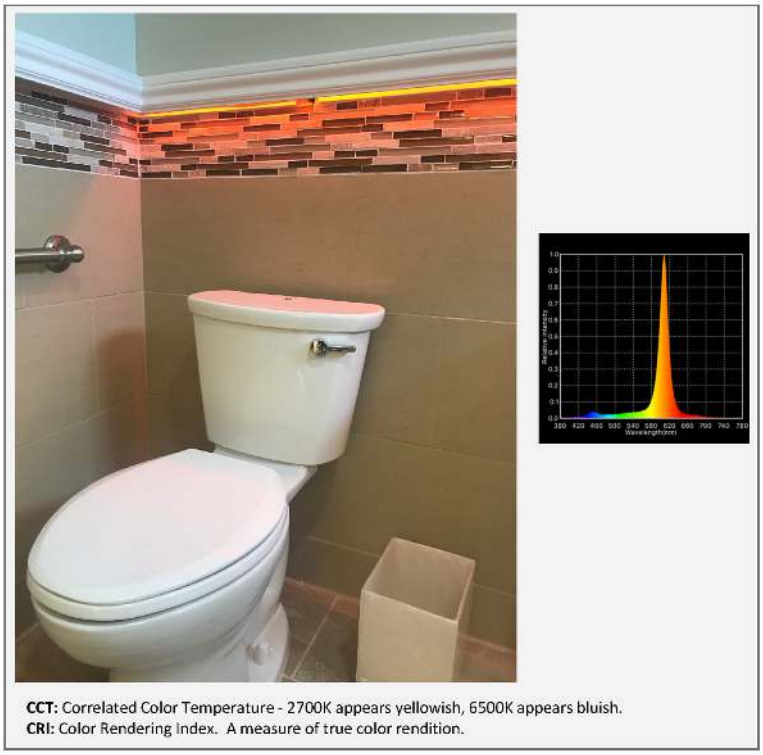


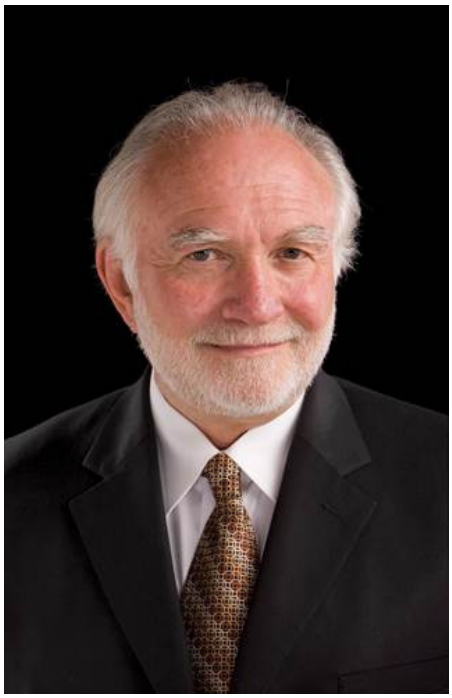
Figure 12: *Bathroom nightlight.*

Meet the Expert

Robert Soler, M.S.
VP Human Biological Technologies and Research
Biological Innovations and Optimization Systems, LLC (BIOS)

Robert Soler leads the Human Biological Technologies and Research at BIOS. Prior to his work with BIOS, his most prominent work was with Kennedy Space Center, where he helped design and build the first LED light for use on the International Space Station (ISS) and collaborated with scientists to use LED light for photo biological purposes in space. Robert's years of experience as an electrical and lighting engineer have led him to become an inventor of 73 issued patents in the U.S. He has authored several published papers on light and its use for air and water disinfection and for human health benefits, with an emphasis on its use in spaceflight applications. After his work at NASA and before joining BIOS, he led the research team in the development of the ISS photobiologically corrected white light that is responsible for circadian entrainment of astronauts and the spectrally tunable adaptable light that manipulates spectrum based on its surrounding environment. He holds a Master of Science degree from the Lighting Research Center at Rensselaer Polytechnic Institute, the premier master's level graduate degree offered in the lighting field, and is finishing a PhD in Behavioral Neuroscience at the University of California, San Diego.

Why POE?



By Keith Gray
Director of Applied Research, J+J Flooring Group

This is Important Work: This is important work, which my colleagues from the SAGE POE team shared with you throughout this document. This work actually began, for me, nearly three years ago, at the SAGE POE presentation at the Environments for Aging Conference in Austin. This is where the idea of J+J collaborating with SAGE to build a sustainable platform to conduct post-occupancy evaluations of physical environments for older adults first crystallized.

I left that session with two clear impressions: 1. that the SAGE POE's are a critical tool in the evolution of the senior lifestyle experience and that, 2. The information contained in the SAGE POE is both anticipated and valued.

I consistently challenge myself to put myself in the place of that person who will learn from my work. And my measure of success is being able to share with them just one small bit of information that changes what they do in a meaningful way, every day. That is what I hope we have accomplished through the 2018 SAGE Post-occupancy Evaluation, subsequent presentations, and this white paper.

That Which Gets Measured Gets Improved: As one who finished graduate school and began my industrial career in the late 1980s, I was immediately exposed to--and embraced--the teachings of the "quality" movement being implemented by manufacturing industries, as expressed very compellingly by "That which gets measured gets improved". There are not many statements that are universally true. This statement is.

continued

As I see it there are two possible interpretations within this statement that relate to this project: one is that by conducting post-occupancy evaluations, and by analyzing and openly sharing what we learn, we will absolutely enhance the life experiences of seniors, even as we strive to define exactly what that is. The second is that as we conduct POE's, the POE process itself will be measured and will improve and will eventually meet one of my personal goals, which is to make POE's a part of every project.

A Rising Tide Lifts All Boats: Everyone wins when organizations like SAGE and J+J come together to address the many challenging questions faced by senior living, in its many embodiments, and apply what we learn to everyone's benefit. I look forward to J+J's continued involvement in the 2019 SAGE Post-occupancy Evaluation of LivGenerations Ahwatukee in Phoenix, Arizona.

SAGE is grateful for J+J's support of the SAGE Post-occupancy evaluation.

By Mitchell Elliott, AIA
Principal
RDG Planning & Design
SAGE President

The Post Occupancy Evaluation (POE) process has been a key initiative over the 20 years of SAGE's existence. The POE process reinforces SAGE's mission involving evidence-based design that contributes to quality care and quality life for older adults. The POE allows our profession to prove that design matters. Our collaboration with J+J Flooring Group in the SAGE POE extends well beyond flooring considerations. J+J Flooring Group's passion for research aligns with our commitment to measuring the impact that design can have in the lives of older adults through the built environment. We are grateful to everyone who has contributed to this robust white paper that extends well beyond a summary of the POE process. This white paper is thought-provoking and will serve as a catalyst for better design, better outcomes and better experiences for those who live and work in our senior living communities.