

A Case for Circadian Lighting in Federal Buildings

It's 5 a.m. on a cold winter morning. The wind is howling, a few clouds are swirling overhead, and a day's old snow is covering the grass. Having just finished packing his lunch, Jimmy Smith grabs his work bag and walks to his car to begin his long, dark commute to work in the big city. Jimmy works in a federal building and will drive his car 20 minutes to a commuter station where he will then board a train that will take him the remaining 45 minutes into town. Once



Jimmy arrives in the city, often before sunrise, his usual routine takes him to a local coffee shop where he orders a triple espresso, the first of three trips to the coffee shop he'll make that day. Jimmy next walks the three blocks to his office where he climbs four flights of stairs and walks down a narrow, dimly-lit hallway to his cubicle to start his day.

By 11:00 a.m., Jimmy is exhausted and has to get another caffeine jolt so he can remain alert to continue his workday. On most days, Jimmy will leave his cubicle to go home around 4:30 p.m. and will arrive back home around 6:00 p.m. During the winter, he rarely sees the sun as he leaves for work and returns from work when it is dark outside.

What is missing in Jimmy's daily routine? The presence of light! While this story may sound like



the beginning of a fiction novel, it is the current reality of a lot of people working in office buildings. Health and lighting researchers, interior designers, building owners, even the federal government have started to invest more resources into studying the connections between light and the health of people working inside buildings. The nexus of light and health is a topic of conversation that is growing by the day, and it is something that anyone who works indoors should better understand. But let's start at the beginning.

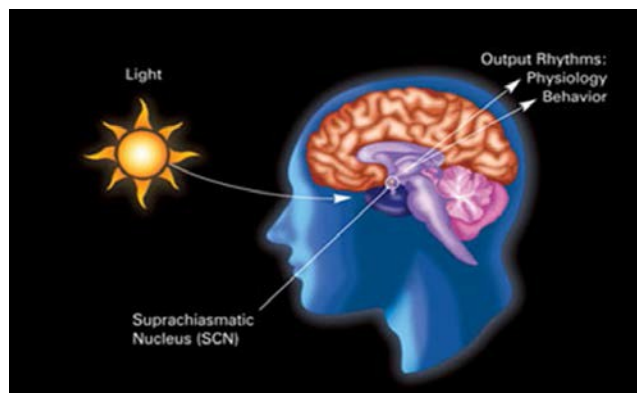
Connection between light and health

Light has three basic functions, all of which have different pathways in the brain: the first is light for vision so a person can see; the second is light to convey information such as a traffic light indicating red to stop and green to go. The third function of light is to maintain the body's circadian system to the solar day so that the wake/sleep cycle is in synch with natural cycles.

While the first two functions are very important, it is this third function of light that many believe has the greatest benefit to people's health and well-being through impacts on the body's circadian rhythms.

A person's "body clock" is regulated by circadian rhythms, which are physiological processes that occur approximately every 24-hours. These 24-hour rhythms have also been widely observed in plants, animals, fungi, and even bacteria. An example of a circadian rhythm is your wake/sleep cycle. Depending on many external factors, you typically wake up when it is light and go to sleep when it is dark each day. Cognitive functioning is also another example of something driven by the circadian system. You may be able to do highly complex tasks such as mathematics in the morning, but have more difficulty later in the day and at night when you are less alert. Light, especially daylight, has an alerting effect. You are not the same person in the morning as in the evening.

No matter whether from the sun or from a man-made source, light enters the eye and travels up the optic nerve to a portion of the brain called the suprachiasmatic nucleus where it evokes a biological response. That response can be both physical and behavioral. Since a function of light is to entrain the body's circadian system to the solar day, if your circadian rhythm is entrained, you sleep well at night and are alert and active during the day. On the contrary, if your circadian rhythm is not entrained to the solar day, you are more likely to experience poor sleep quality at night and be less alert and less active during the day.



Absence of Light: A Cause for Concern

The biological systems that underlie much of human behavior evolved in a natural world where people lived and worked outdoors during the day and sat around the campfire sharing stories at night. The industrial revolution forever changed all of this, and humans moved indoors to work, live, and play - away from daylight. The advancement of electric lighting in the 20th century provided widespread access to light at any time of the day, which further removed people from needing to harness daylight in their daily lives.



As seen with Jimmy Smith, sometimes people go to work and leave from work in the dark. As a consequence, when do people see the light? Well, it happens at work. A study from the Harvard School of Public Health concluded that

people spend over 90% of their time indoors¹, and the vast majority of people's waking hours are in the office. Numerous health studies have found correlations between circadian rhythm disruption and chronic disease and health problems such as poor sleep, higher stress, heart disease, diabetes, and even higher incidences of breast cancer. People are starting to take notice; so much so that this topic has been brought to the mainstream through green building conferences, interior design forums, even Ted Talks. People are talking about it, but what is actually being done?

GSA Research on Circadian Light

The shift from being outside all the time to being inside most of the time presents both a public health concern and a call to action. It is precisely why the U.S. General Services Administration (GSA), the nation's largest public real estate organization, became interested in circadian light. GSA has a diverse portfolio of almost 8800 assets housing a federal workforce of 1.1 million people and over 400 different agencies, bureaus and commissions. This constitutes a little less than 380 million rentable square feet of space split between government-owned and leased properties.



With such a stock of buildings, GSA has an opportunity to optimize the luminous environment within its buildings to improve the health and well-being of its tenants. GSA has been working to improve buildings from the occupant's perspective for a long time. For instance, GSA prohibited smoking in its buildings and near building entrances and intakes long before this was law.



Although there is a large body of research on light for vision, much less is known about the building occupants' experience of light and how it influences their circadian functioning. GSA and researchers from the Lighting Research Center (LRC) from Rensselaer Polytechnic Institute are filling this

knowledge gap by studying the connections between light and the health and well-being of people in buildings.

Study Sites in 5 GSA Buildings

GSA and the LRC have conducted research at five GSA buildings across the country:

¹ J. Spengler, Harvard School of Public Health, 1983

- Edith Green-Wendell Wyatt Federal Building in Portland, Oregon
- Federal Center South Building 1202 in Seattle, Washington
- GSA Headquarters building in Washington, D.C.
- GSA National Capital Region Regional Office Building in Washington, D.C.
- Wayne N. Aspinall Federal Building and U.S. Courthouse in Grand Junction, Colorado

The research took place at each building both in the winter and summer to account for seasonal variability in the length of days and the sun angle.

What GSA is Learning from the Research?

While GSA and the LRC are continuing to collect data, several preliminary findings support the case for more circadian light in buildings.

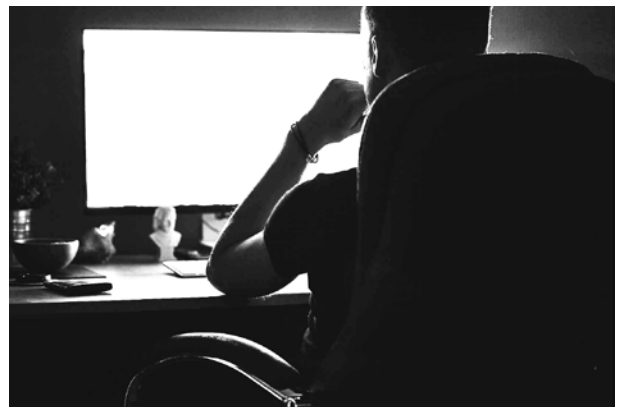
1. **People were exposed to more light while at work than anywhere else.**

In GSA's research, exposure to sufficient circadian light at work showed slight improvement in some measures of sleep, alertness, and mood. Research participants who received sufficient circadian light tended to be more active during the daytime and slept better at night. Circadian light also helped participants fall asleep more quickly at night and spend more time asleep and less time tossing and turning while in bed. Those who did not receive sufficient circadian stimulus during work tended to be less active during the day and more restless while sleeping at night, and these same people self-reported more instances of sleep disturbance. This indicates that people who receive sufficient circadian stimulus from daylight or electric lighting are entraining their circadian rhythm to the solar day. This also shows that there is an opportunity to influence the circadian functioning of building occupants while they are at work. Based on previous research and available literature, the best time for circadian entrainment is in a well-lit area in the morning for at least 30 minutes.

2. **The benefits of circadian light at work were slightly better in winter than in summer.**

In the winter, research participants who received sufficient circadian stimulus tended to sleep better at night and spent less time awake while in bed. However, in the summer, people reported more instances of sleep disturbance. One possible explanation for the increased reports of sleep disturbances may be that people are receiving too much daylight late in the day because they are more active after work when the sun is still up.

As a result, the increased exposure to daylight disrupts the person's circadian entrainment and potentially causes sleep problems and sleepiness the next day during work. Further research is needed to confirm this.



3. Sometimes, daylighting alone cannot provide sufficient circadian stimulus.

Even in well-daylit buildings, there are pockets of biological darkness and low levels of circadian stimulus. A small percentage of people experienced *daylight-enhanced* circadian functioning, but the vast majority did not due to such factors such as low penetration of daylight into the interior, extensive use of shades, and interior design factors that limited light transmission to the eye. This suggests that daylight may need to be supplemented by electric light solutions to provide sufficient circadian stimulus in the workspace.

4. Shade use, primarily to reduce glare on computer screens, also reduces circadian stimulation if shades are not adjusted when glare is no longer a problem.

Workspaces are typically designed around where the computer sits on the desk, and computers are a key driver of shade use and other daylight reducing behaviors. Glare and other challenges occur when building orientation, light reflecting off of adjacent buildings, and placement of overhead lights are not taken into consideration during workspace design. Oftentimes, once people lower shading devices, they do not raise them when they no longer need them. Not only does this limit their circadian stimulus, it also impacts those sitting around them.

5. Designing the interior of the workspace is an interdisciplinary problem-set.

Lighting design requires integrated thinking. Design for circadian stimulus should be an exercise involving multiple stakeholders, including the end-user (customer), prior to finalizing decisions.

While the overall effect witnessed in GSA's research is relatively small for each of the outcomes related to sleep, alertness, and mood, when we take into account the combined effect of numerous positive outcomes, the overall value of circadian stimulation at work is magnified.

The last preliminary finding above confirms that circadian lighting is an ecosystem of three distinct parts: Daylight design including windows, controls, and how both are integrated with electric lighting technologies; interior design including the type of furniture in the workspace, layout, colors, finishes, computer ergonomics; and the organizational system of the entity in the workspace including the workplace culture, occupant behavior, nature of work, reward structure, and work technologies used in the space. All of these parts have an impact on the circadian stimulus of occupants in the workspace, and suggest systems thinking and cross- collaboration between stakeholders must occur. While this can be accomplished more easily during workspace renovations or new construction, how do we optimize the



luminous environment in workspaces that are not being renovated? Although challenging, this is not impossible, and GSA is beginning to explore various best practices that it can promote to its employees and tenants for people to get the necessary circadian entrainment whether through behavioral modification, workspace patterns, or through the use of market-available technologies that can mimic daylight in workspaces with no access to daylight. In particular, GSA is currently working with several other Federal agencies in testing the efficacy of using supplemental electric lighting solutions in workspaces to determine whether we can provide sufficient circadian stimulus potential in deep interior workspaces with little to no access to daylight.

It's time to bring circadian light into buildings to promote the health and well-being of the people working in them! Access to circadian light is a right and should be something readily available to anyone working in a building. While the science behind circadian light is still growing, the message is getting clearer by the day: get light - mostly daylight - morning best!

