

Impact of office lighting on cognitive performance and sleep

Lighting in a home or office is much more than aesthetics. It can help us see better, perform better and be more productive. Our sleep, health, moods, behavior and comfort can be affected. Most people now spend about 90 percent of their time indoors, and electric lighting has become our primary light source. We are exposed to less natural blue-enriched light from the sun during the day, which can increase our alertness and reset our biological clocks to help us sleep. Given the positive benefits of daytime exposure to blue-enriched light, the Well Living Lab sought to measure the effects of different types of lighting on cognitive performance during the day and subsequent sleep at night in a 12-week study:

- Seven employees relocated to the Well Living Lab's simulated office space where they carried out their typical work duties. They experienced two types of lighting during the study:
 - A baseline fluorescent lighting condition that matched their previous office
 - Blue-enriched white LED lighting
- Six other employees from the same work unit remained in their existing office area with fluorescent lights
- Since the group that remained in their existing office did not have access windows, neither group had office access to daylight. This helped control the effects that daylight might have on the outcomes.
- Both groups completed a series of cognitive tasks and surveys:
 - Three cognitive tests measured task-switching, working memory and the ability to focus on relative information while suppressing interference from irrelevant information (inhibitory control). These tests helped study executive function, which encompasses the cognitive functions necessary to form goals, plan and execute goal-directed behaviors for typical work performance and everyday life.
 - Daily surveys about the impact of lighting on their satisfaction with the environment, perceived productivity and symptoms of eye strain and headache
 - Daily reporting of caffeine, exercise, mood, alertness and mindfulness practice
 - Reporting of time spent in the office
- All employees used a wearable device to measure sleep behaviors, kept sleep diaries to report sleep behaviors and bedtime habits and completed surveys to measure perceived sleep quality.

DEFINITIONS

Light

Light is a type of energy composed of different colors. Each color is made up of a specific wavelength and frequency and the combination of these wavelengths make up visible spectrum. The order of the spectrum from longer wavelengths to shorter wavelengths is red, orange, yellow, green, blue and indigo (or ROY G. BIV.)

Blue-enriched white light

When a specific light source is predominately made up of light from shorter wavelengths in the blue range of the visible spectrum (~450 - 480 nm) it is called blue-enriched white light. Special receptors in the eye that control our sleep/wake cycle are sensitive to blue-enriched white light. Specifically, exposure to blue-enriched light can suppress melatonin, a hormone that cues our body to when it's time to sleep, which can increase our feelings of alertness. During the day this is beneficial, however at bedtime this can negatively impact our ability to sleep.

Fluorescent light

Fluorescent lighting is a type of lighting technology that depends on a chemical reaction of gases and mercury vapor interacting to produce an invisible Ultra Violet (UV light), which, in turn, illuminates a phosphor powder coating the inside of a glass tube to emit a white "fluorescent" light. Fluorescent light is typically found in commercial buildings such as offices, hospitals, schools, retail spaces and warehouses. It's considered a fairly energy efficient light source and also inexpensive. However, flickering and glare from the chemical reaction can increase the incidence of headaches.

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- Task-switching performance improved when office workers were exposed to blue-enriched LED lighting compared to fluorescent lighting. This may indicate that blue-enriched LED lighting is beneficial for professionals who do a lot of multi-tasking or responding to interruptions, including jobs in management or emergency medicine.
- Working memory and inhibitory control were not impacted by the different types of lighting.
- Employees felt that the blue-enriched LED light supported their personal productivity during the day.
- Perceived ratings of alertness, mood and environmental satisfaction did not change between lighting conditions.
- Daytime exposure to blue-enriched white light led to mixed sleep findings. Although people slept longer when they had been exposed to blue-enriched light during the day, they might have woken up more during the night, indicating that while they slept more, their sleep was not necessarily restful. However, overall, both groups of office workers woke up more during the second half of the study, which suggests that the increased awakenings experienced during the blue-enriched LED condition may have been due to other factors not measured in the study.
- Exposing office workers to blue-enriched LED lighting without other lighting sources, such as daylight, may yield limited benefits. For example, electric light may not be sufficient to improve alertness during the day or fully impact sleep at night. Access to natural light may be needed.

DEFINITIONS

LED light

Light-emitting diode (LED) is a semiconductor device that produces light when electricity is sent through it in a specific direction. Like fluorescent lights, they are energy efficient compared to a typical incandescent lightbulb. However, unlike fluorescent lights, they do not emit UV rays, which reduces the strain placed on the eyes. LED lights can be used in people’s homes and, increasingly being used in newer commercial spaces.



ABOUT THE WELL LIVING LAB

The Well Living Lab, a collaboration of Delos™ and Mayo Clinic, is dedicated to identifying how indoor environments impact human health and well-being. It conducts scientific research with human subjects in a simulated real-world environment and shares practical findings that can be applied to improving indoor spaces where most people spent approximately 90 percent of their time. The lab has 5,500 square-feet of sensor rich, reconfigurable space in downtown Rochester, Minnesota.

Learn more at WellLivingLab.com

BLUE-ENRICHED WHITE LED LIGHTING VS. FLUORESCENT LIGHTING				
Activity	No Effect	Positive Effect	Negative Effect	Notes
Task Switching		✓		
Memory	✓			
Sorting relevant/irrelevant information	✓			
Satisfaction with environment	✓			
Perceived productivity		✓		
Perceived alertness	✓			
Amount of sleep		✓		23 more minutes per night
Awakenings after falling asleep			✓	7 more minutes of awake time
Length of time before falling asleep	✓			
Amount of time in bed asleep vs. awake			✓	Marginal negative effect
Eye strain	✓			
Headaches	✓			
Mood	✓			