



EVOLV

Establishing the value of light and views



Executive Summary

An innate relationship with daylight and views

For the bulk of human history, we have been an outdoor species and have evolved to thrive in the natural environments around us. Access to daylight and views of nature are not only preferable attributes of a workplace but also physiologically tied to our health and wellbeing. Nearly all organisms have developed circadian systems that modulate physiology and behavior in response to diurnal changes in daylight. Our exposure to daylight, or lack thereof, has a sizable impact on our sleep quality and alertness. Similarly, the biophilia hypothesis suggests that humans have an innate connection to nature, and numerous studies have linked views of nature to stress reduction and cognitive function.

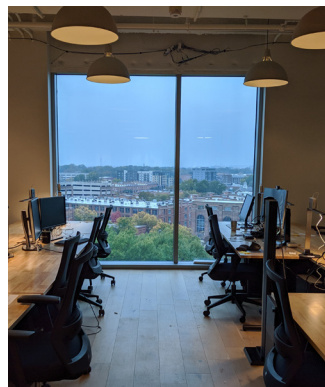
The EVOLV study, conducted by the University of Illinois Urbana-Champaign and SUNY Upstate Medical University, sought to establish the value of daylight and views on people's health and productivity.

Study Design

30 participants relocated from their normal office to spend one week in each of two adjacent office suites:

- One with traditional blinds deployed to desk height
- One with optimized daylight and views achieved by electrochromic (EC) windows, which intelligently tint based on outdoor solar conditions.

Aside from this difference, the offices were identical in layout, location, orientation, and environmental factors such as noise level and air quality. Participants completed daily surveys, wore an ActiGraph wgt3x - a research-grade sleep tracker - to monitor their sleep quality for the duration of the study and completed 1.5-hour cognitive assessments on the Monday and Friday of each week.



University of Illinois Urbana-Champaign and SUNY Upstate Medical University. Boubekri M, Lee J, MacNaughton P, Woo M, Schuyler L, Tinianov B, Satish U. The Impact of Optimized Daylight and Views on Sleep Duration and Cognitive Performance of Office Workers. International Journal of Environmental Research and Public Health. 2020, 17(9), 3219.

Key Findings

When working in an office with daylight and views optimized by using electrochromic windows, participants experienced:

48% less eyestrain and were **77%** less likely to report feeling depressed

37 minutes more sleep per night

42% higher cognitive function scores

compared to when they worked in an office with traditional blinds.

Results

Sick Building Symptoms

The office with optimized daylight and views produced better visual comfort, resulting in a 48% reduction in reported eyestrain. Participants were also 77% less likely to report feeling depressed because of the brighter light conditions and improved views in the office with optimized daylight and views.

Sleep

Participants slept 37 minutes longer per night after working in the room with optimized daylight and views compared to the room with blinds. This benefit resulting from their work environment was found to be greater than the benefit from sleep supplements, which increased participants' sleep duration by only 27 minutes. Poor sleepers (those with a low baseline sleep duration) saw the greatest benefit of 53 minutes of additional sleep per night, improving from an average of 5 hours 45 minutes to 6 hours 38 minutes of sleep per night, while good sleepers realized an average benefit of 18 minutes, going from 6 hours 30 minutes to 6 hours 48 minutes of sleep per night.

Cognitive Function

Participants performed better on all aspects of cognitive function, spanning domains related to activity levels, crisis management, information usage, breadth of approach and strategy, while working in the room with optimized daylight and views. Averaging across the domains, their scores increased by 42%.

The cognitive assessment scores were compared against a normative dataset of over 100,000 previous test takers. Participants shifted from the 52nd percentile in the blinds condition to the 65th percentile in the optimized daylight and views condition. This improvement in performance translates to a 14% increase in productivity.

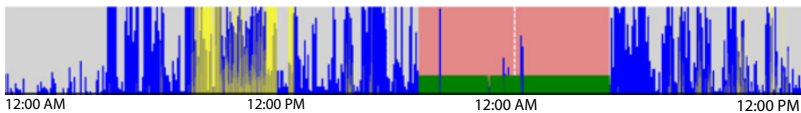
Conclusions

In this study, participants experienced immediate, substantial and sustained benefits to their health, sleep and productivity from working in an office with optimized daylight and views compared to traditional blinds. Corporate executives, developers and architects should consider the significant health, sleep and productivity benefits to people from improved access to daylight and views when designing, constructing and renovating buildings.

Research Methods

This study utilized a crossover design to test the effect of exposure to daylight and views during workday hours on objectively measured cognitive function and sleep. 30 participants relocated from their regular office to spend one week in each of two office environments. The two office suites were adjacent to one another and had an identical floor plan, furniture layout and electric lighting. Thermal, air quality, noise and horizontal lighting conditions were similar in the two offices as measured by environmental monitors at each desk. The one difference between the two test conditions was the façade configuration: one had traditional roller blinds and the other had electrochromic glazing that would automatically and predictively tint based on outdoor solar conditions.

Participants wore a wrist-worn actigraph – the ActiGraph wgt3x, a research-grade 3-axis accelerometer – 24 hours a day over the course of study. The actigraphs collected raw acceleration data, which was then analyzed to determine sleep and wake periods using validated algorithms.



At 3:00 PM on the Monday and Friday of each week, participants completed the Strategic Management Simulation (SMS) assessment, which is a validated, computer-based simulation software. The simulation would place the participant in a decision-making role, such as an emergency planner or city mayor, and over the course of the 83-minute simulation they would be tasked with responding to events that occur under their purview. All actions taken throughout the simulation were processed by the SMS software to provide scores on nine cognitive domains. These domains range from basic (activity levels, information search) to complex (crisis response, information management, and strategy). Unlike other cognitive tests, which isolate individual mechanistic processes (e.g. working memory, attention), the SMS assessment provides a composite approach using real-world scenarios, which ultimately leads to stronger correlations with other indicators of job performance such as salary at age, number of employees supervised, and number of promotions. The assessments have high retest validity, eliminating the concern of a learning effect.

The Study Team



Dr. Mohamed Boubekri

Professor of
Architecture and
Landscape Architecture

**University of Illinois
Urbana-Champaign**



Dr. Usha Satish

Professor of
Psychiatry and
Behavioral Sciences

**SUNY Upstate
Medical University**

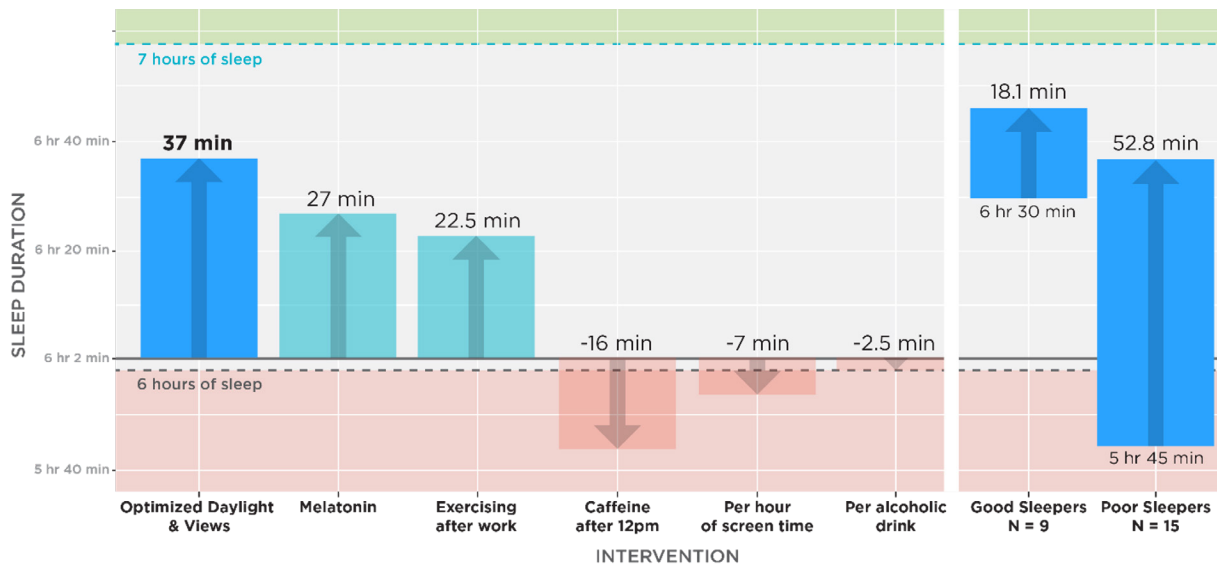
The Results

Fewer Symptoms

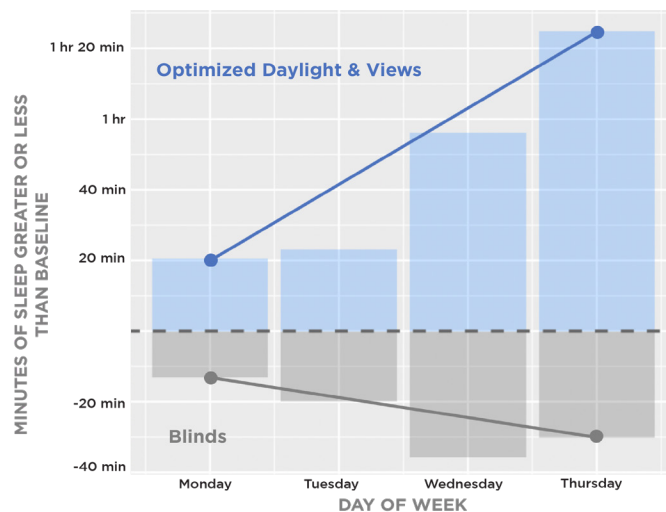
The lighting conditions in the room with optimized daylight produced better visual comfort. The lighting conditions were generally brighter while mitigating the potential for glare, and tracked the color temperature of daylight more closely than the room with blinds. Participants were 48% less likely to report eyestrain compared to when they worked in the office with blinds, which often had light levels that were too dim and which blocked the long distance views that help the eye recover from screen use. The brighter environment in the optimized daylight & views condition, along with the access to views, resulted in a 77% lower likelihood of feeling depressed.

Longer Sleep

Controlling for lifestyle factors that are known to affect sleep (melatonin intake, evening exercise, number of alcoholic drinks, caffeine intake after noon, and evening screen time), participants slept 37 minutes more per night ($p < 0.001$) after working in the optimized daylight & views condition. The effect of daylight and views was larger than the effect of other well-established factors that impact sleep duration, such as the use of sleep supplements and caffeine consumption after noon.



Sleep duration for each participant was compared to their baseline sleep in the week prior to relocating to the office suites. Over the course of the week, the impacts on sleep duration added up: participants accumulated a sleep debt of 30 minutes of sleep over the course of the week in the blinds office. Conversely, participants gained 1 hour and 25 minutes more sleep than normal while in the optimized daylight and view office suite. The effect of optimized daylight and views varied based on participants' baseline sleep quality. Participants were categorized as either 'good' or 'poor' sleepers based on their sleep quality prior to relocation. Poor sleepers averaged 5 hours 45 minutes of sleep, while good sleepers averaged 6 hours 30 minutes during the week prior to relocation. Controlling for lifestyle factors, poor sleepers gained 52.8 minutes of sleep ($p < 0.001$), while good sleepers gained only 18.1 minutes of sleep ($p = 0.214$), indicating that those who benefitted were those who needed it the most.

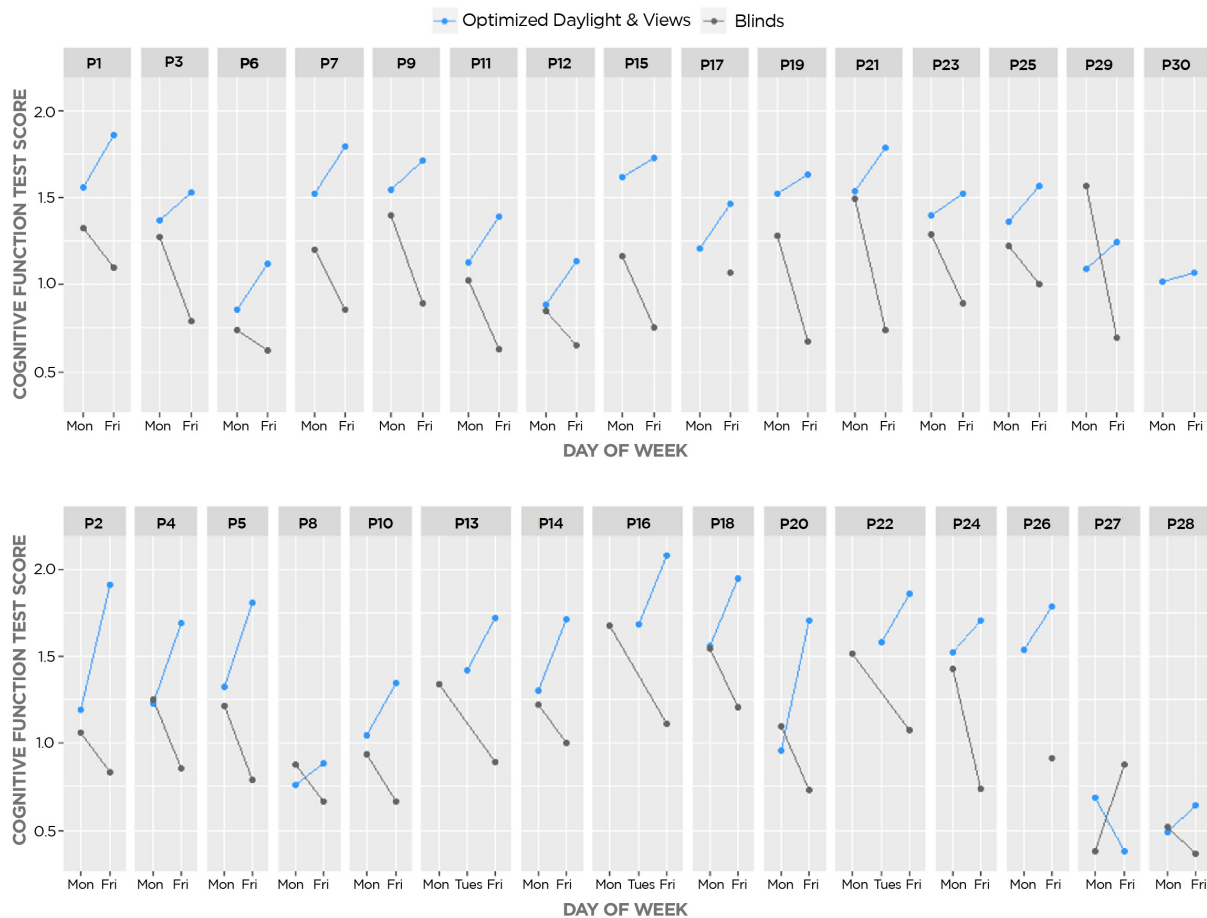


Improved Cognitive Function

The results of the SMS tool indicated 26-62% higher cognitive function scores across all nine domains of strategic thinking. These domains, each relating to the ability to set, develop, and fulfill goals and tasks, gather and manage available resources to improve organizational effectiveness, plan actions and strategize successful outcomes, and weather any crisis and emerge with lessons for future success, are critical indicators of work-related performance.

Models of the effect of the office condition on the cognitive scores, controlling for the effect of the indoor temperature on the day of the assessment, demonstrated that participants scored on average 42% higher across the nine domains when in the office with optimized daylight and views compared to when they performed the simulation in the office with blinds ($p < 0.0001$). Temperature exhibited a U-shaped curve with optimal cognitive function scores between 72°F and 73°F. Over 25% of the variability in test scores were explained just by the room they were in when they completed the assessment.

Plotting the normalized scores on each assessment for all 30 participants reveals a high degree of consistency in the effect of the office condition on cognitive function across individuals. The plots suggest both an acute and cumulative benefit of working in the optimized daylight & views condition. Nearly all participants scored higher on the Monday in the optimized daylight & views condition compared to the Monday while in the blinds condition, demonstrating the acute benefit of optimized daylight and views. In addition, nearly everyone's scores increased after having access to daylight and views throughout the week and decreased after spending a week in an office with blinds, indicating cumulative impacts on cognitive function with increased exposure.



Increased Productivity

A subsequent analysis sought to estimate the economic implications of improved access to daylight and views. The cognitive scores for the participants in each job category were compared against over 100,000 previous test scores to obtain the distributional shift in cognitive performance when working in an office with optimized daylight and views as opposed to an office with traditional blinds¹. This benefit to cognitive performance was then compared against representative salary data to determine the impact on productivity².

Participants scored at the 52nd percentile when working in the blinds condition, indicating that they were representative of the U.S. workforce, and shifted to the 65th percentile of cognitive performance when they moved to the optimized daylight & views condition. Based on representative data from knowledge workers who have taken the SMS test previously, each percentile increase in test performance is associated with a \$791-\$1,113 increase in salary. Thus, the average change of 13 percentiles in cognitive function corresponds to a \$10,268 change in salary per year – or a 14% increase in productivity. For managers, this is equivalent to an estimated salary difference of \$15,882 per year, and for technical employees, an estimated salary difference of \$7,823 per year.

Salary estimates for employees in an office environment with static blinds compared to those in an office with optimized daylight & views

Occupation Type	Blinds	Optimized Daylight & Views	Difference
Managerial	\$149,776	\$165,648	\$15,882
Technical	\$94,231	\$102,054	\$7,823
Professional	\$94,231	\$101,549	\$7,318
Administrative	\$54,286	\$66,958	\$12,672
Weighted Average	\$87,118	\$97,386	\$10,268

Conclusions

Participants in an office with optimized daylight and views reported fewer symptoms, slept 37 minutes longer and scored 42% higher on cognitive assessments than when they worked in an office with blinds. The benefits to sleep and cognitive function were immediate, substantial and sustained over the study period. By improving cognitive performance of employees, optimizing daylight and views has the potential to create substantial economic value on the order of \$10K per employee per year.

These findings suggest that building developers, architects and tenants should give additional attention to the impacts of daylight as they consider new building construction, architectural design and leasing options.

¹ MacNaughton P, et al. 2021. Economic implications of access to daylight and views in office buildings from improved productivity. *Journal of Applied Social Psychology*.
² MacNaughton P & Cockerill A. 2021. Validity of the Strategic Management Simulation to predict real world productivity. *Journal of Applied Social Psychology*. In press.