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What You Ignore at Work May Harm You: the Effects of Light, Design, and Nature

Shelby Beutel

Abstract: This article looks into the effects of light, design, and nature on employees by incorporating environmental health and environmental design research into useful suggestions for the employee and the employer. The “fit” between a user and their work space has been elaborated on in recent years, and it has been shown that insufficient lighting can cause poor “fit” and consequential draining of energy and productivity. In the healthcare setting, medication errors have been linked to the amount of lighting within a hospital and to the variable amount of daylight throughout the year. While there is not a quick and easy test to determine an individual’s ideal work environment, there are both small and large changes that can be made to improve one’s health and well-being.

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If you could change one aspect of your work environment, what would it be? Perhaps you would like to alter who you work with, the decorations, the cleanliness of the space, or the location of the building. These are all valid concerns, but have you ever thought about the lighting?

Not all light is the same. Sunlight versus artificial light, light-emitting diode (LED) versus incandescent, and full spectrum versus narrow spectrum are all different examples of lighting. Do these variations really matter? The discrepancies are less important in a home setting where you typically control the lighting and have fewer visual demands, but at work, productivity is key.

Light could be an overlooked factor that affects employee productivity. In addition to light, what are other related and often overlooked factors that have significance for employees? With these thoughts, I became interested in what science has shown for the work setting, where productivity is essential, and how this can affect one’s workplace life and health.

LIGHTING REGULATIONS

Building codes determine the foundation of the work environment, and have standardized requirements regarding lighting. Many building codes in the Western world “promote the use of daylight and discourage the use of cool fluorescent light” in healthcare and office settings.¹ This is because the “evidence on the positive effects of daylight and negative effects of cool fluorescent light is so strong.”¹ Some European countries even specify a maximum distance from a window for employee workspace due to direct physical and mental benefits.¹

A factor often overlooked is electric light, which in contrast to daylight, is more uniform and consistent. In 2005, the U.S. Green Building Council created a widely accepted building standard called the Leadership in Energy and Environmental Design – New Construction (LEED-NC).² A criterion of the LEED-NC version 2.2 states that three-quarters of all regularly occupied areas must achieve “a minimum glazing factor of 2%

or at least 25 foot-candles (269 lx).”² This simply means that the measurements of light in the LEED criterion are focused on quantity of light, measured by the glazing factor or foot-candle, while the source and quality of light are not specified.

Lux (lx) is a standardized measurement of light intensity or brightness; “illuminance” is another synonym that is often associated with lux.^{3,4} Foot-candles are an alternative unit of illumination commonly used in the United States.⁴ One lux is the illumination one meter away from one standardized candle,³ while one foot-candle is the brightness that falls on a one square foot surface surrounding the light of one candle.⁴ For example, on average, offices are often around 400-500 lx, and full daylight outside can range from 32,000 lx to 100,000 lx.³

Lighting regulations create minimum lighting standards to help ensure health and safety. Adjusting lighting conditions in an office can affect workers in three ways: changing what they can see, their visual comfort, and their perception of the environment.⁵

ENVIRONMENTAL COMFORT

While not all aspects of the environment are of equal importance, some common ground has been found. In response to facilities facing pressure to “reduce space allocation ... in open-plan offices, as a means to reduce cost,” a multidisciplinary group formed the Cost-effective Open-Plan Environments (COPE) project.⁶ The COPE project created “a statistically significant model that link[ed] lighting, ventilation, privacy, and acoustics to overall environmental satisfaction.”⁷ Furthermore, overall environmental satisfaction in an open-plan office had a positive correlation with predicted job satisfaction.^{6,7} Environmental variables and design variables are considered two separate areas underneath the umbrella of design, but they can overlap. For example, color, which is a design variable, can enhance or deteriorate lighting, an environmental variable.¹

In 2005, Jacqueline Vischer suggested that there are three hierarchical categories of environmental comfort—physical, functional, and psychological.⁸ The environmental comfort model postulates that optimal environmental support occurs when all three categories of comfort are fulfilled. Strength in one category can compensate for poor environmental support in another, but this is not ideal. Physical comfort has value due to basic needs, such as safety, hygiene, and accessibility. Functional comfort has value based on measurement, such as ergonomic support.⁸ Psychological comfort, the highest level of the three categories, has value based on process, such as “feelings of belonging, ownership, and control over workspace.”⁸

FIT, MISFIT, AND COPING

Researchers have elaborated on the fit between users and their workspace in recent years. Fit refers to optimal environmental support within each category of comfort. Lighting is often considered a functional comfort. Insufficient lighting can lead to poor fit and consequential draining of energy and productivity.⁸ A major concern with fluorescent lighting is the presence and effect of a “flicker”, where the lights turn on and off quickly.⁹ Several studies have shown that low-frequency flicker can “interrupt saccadic eye movements, reduce visual performance, and increase the incidence of headache and eyestrain.”⁹ However, high-frequency fluorescents are much more common today and do not seem to have the same sensory response.^{9,10} There are a variety of scales and tests that can be used to evaluate preferred luminous conditions, mood, and work performance.^{5,11} A recommended practice for illuminance in offices with computer screens is 300-500 lx.¹² Having the ability to dim desk lighting, however, can be vastly beneficial.⁵ On an individual basis, trial and error within recommended ranges of illuminance may be best.

A distinction should be made between satisfaction with aesthetics and visual comfort for performance.⁵ Boyce et al. concluded that performance with visual jobs may be determined by the amount of stimuli the tasks provide, and by the lighting conditions in the immediate area.⁵ In contrast, one’s impression of an area includes details beyond necessity, such as the appearance of the lighting fixtures and the office as a whole.⁵ Therefore, the best working environment may not be the same as an individual’s choice in lighting or aesthetics.

“Misfit,” as defined by Vischer, occurs when the “environment places inappropriate or excessive demands on a user” in spite of the adjustments that a person makes.⁸ For example, misfit can occur when a worker is squinting to see his or her work because there is not enough light. The amount of attention and energy occupants use to adapt and cope with adverse conditions is a key difference between unsupportive and supportive workspaces.⁸ “Coping skills can be behavioral, physiological, psychological, or cognitive in nature.”¹ However, any number of combinations are possible, and the context of a stressor can change the effectiveness of coping strategies.¹ Workplaces that allow personalization and individual decoration

are encouraging a form of ‘emotion-focused’ coping behavior through empowerment.⁸

Design elements can promote positive health outcomes by facilitating effective stress coping mechanisms and restoration, and these positive health effects have been linked to savings in healthcare costs.¹³ In contrast, poor designs have been linked to anxiety, elevated blood pressure, and increased use of pain medication.⁵ Improper lighting, in particular, contributes to depression, headaches, seasonal affective disorder (SAD), and eyestrain.^{1,14}

LIGHT IN HEALTHCARE

Healthcare focuses on well-being not found in all environments. Exposure to daylight benefits both patients and staff in a hospital setting. An investigation of 141 nurses at a university hospital found that nurses with increased exposure to daylight experience less burnout.¹⁵ Chaudhury et al. found that “[b]right lights improve patient outcomes, and exposure to sunlight results in improved health.”¹⁶ Studies also suggest that high illumination levels can lead to fewer errors, and additional exposure to natural light has a positive impact on staff members.¹⁶ Buchanan et al. found that medication errors with lighting at 450 lx occurred at a frequency of 3.8% compared to 2.6% with illumination levels at 1500 lx.¹⁶ In 2006, Ulrich et al. suggested that illumination levels of 1500-2000 lx may be needed to reduce errors for hospital-based tasks like dispensing medications.¹⁶ Even with the aforementioned evidence, it is still uncertain, however, what circumstances are or are not affected by the amount of light. For example, “some studies have failed to identify significant effects of illuminance” while other studies have found low illuminance to be a significant influence on reading performance.¹

While healthcare errors can directly harm people, all work suffers when errors occur. In a study performed in Anchorage, Alaska, 58% of all nursing staff medication errors occurred between January and March, when there is less daylight.¹⁷ Anchorage experiences ~14 hours difference in daylight between the summer solstice in June and winter solstice in December. The best statistical prediction of errors was the level of darkness two months prior to the observed errors.¹⁸ Therefore, the effects of the limited daylight in December were manifested in the errors occurring the following February. Researchers cited biological plausibility, based on what is known about the patterns of depressive episodes and SAD.¹⁷ The severity of the errors was not examined during this study, but the uneven distribution of errors is noteworthy.

WINDOWS AND NATURE AT WORK

Many people prefer windows in an office setting, but not all see their value.¹⁸ Some workers may desire to have exposure to daylight, while others are easily bothered by the changes in lighting throughout the day. According to a 2011 study by Wang and Boubekri, sunlight penetration between 15-25%, and

up to 40% being acceptable, seems to be optimal for relaxing tasks.² The best location for cognitive tasks includes a site close to a sun patch on the floor, with a sense of control and privacy. For this study, control was defined as a participant's ability to adjust his or her exposure to the surroundings, and privacy was defined as "the level of visual isolation from the environment."² The results suggest that being located directly in a sun patch is not as beneficial as simply being near one. It is important to note that Wang and Boubekri found that the ability to adjust to one's surroundings appears more important than an outdoor view, when both isn't an option.² Wang and Boubekri provide specific suggestions for desk layouts in regards to daylight for single-occupancy, double-occupancy, and open office spaces. The optimal zone for a desk is never within range of direct sunlight but within sight of a window. In an open-office plan, spreading desks out allows for greater privacy and room circulation compared to having aisles located around a clump of desks.²

For those working in offices without windows, going outside for lunch breaks may be beneficial or worthwhile. Directly interacting with nature was shown to improve cognitive function in a 2008 study by Berman et al.¹⁹ A walk in a park setting helped participants repeat digits backwards better than a comparable walk in a busy downtown setting. Both walks were 2.8 miles in length, taking about 50-55 minutes to complete. On average, the urban walk helped participants remember 0.5 digits more than before the walk, while the nature setting participants remembered 1.5 digits more.¹⁹

Indirect interactions with nature may be a more practical means of compensation for lack of daylight hours. In a 2011 study by Bringslimark et al., a worker without windows had "roughly five times greater odds of having brought plants into their workspaces ... and over three times greater odds of having brought pictures of nature into their workspaces."¹⁸ Personalization can be a confounding factor when studying compensation in a windowless office setting. However, Bringslimark et al. treated pictures of familiar people as an indicator of personalization, and these pictures were considered weaker substitutes versus plants or pictures of landscapes.¹⁸ Bringing in plants and/or pictures is a form of "emotion-based" coping related to environmental comfort.⁸ Personal indoor plants are more common with employees that have other workspace decorations, fewer work demands, and no windows.¹⁸

There are positive outcomes attached to these indirect interactions with nature. In a study of 120 people, healthcare patients fared better during a painful bone marrow aspirate and biopsy when viewing a mural of nature and hearing nature sounds.²⁰ Sights and sounds of nature decreased the odds of moderate to severe pain by roughly 75% compared to the patients receiving standard care without these nature additives.²⁰ In a 2008 study by Dravigne et al., office workers with both windows and plants, as well as those with plants but no windows, rated their overall job satisfaction and quality of life higher than those with windows but no plants, and those without both.²¹ There were also statistical differences in satisfaction with the participants' type of work, supervision, and coworkers.²¹ Involving nature directly or through pictures and recordings may be one way to help change employee moods, induce pleasant

thoughts, and allow the body to relax. These effects can start in as quickly as five minutes.²²

APPLICATION TO THE EMPLOYEE

Several aspects of organizational productivity are affected by job satisfaction.⁷ Well-being is at the core of outcomes such as "customer satisfaction, employee sickness and turnover, and voluntary overtime."⁷ The aforementioned health benefits of light, design, and nature discussed in this article can be incorporated into your own workplace. To better your health and well-being, consider bringing in plants and additional lighting, getting outside, and adapting when your surroundings are misaligned with your needs. Light and environment certainly seem to play a significant role in mood, memory, and productivity, so it is best not to take them for granted.

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