



interact Office

White paper

Creating engaging office environments

Light for the heart, light for sight, light for the mind

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Shifting priorities, new approaches

Recent years have seen a shift in approaches to office design. Purely functional workspaces have started giving way to spaces that are designed to engage and inspire. Employers are increasingly realizing that people represent not only their highest cost but also, and more importantly, their greatest asset. As a result, they have been focusing on workplace design as a way of attracting talent, retaining high-value employees, and enhancing organizational performance.

Human resources professionals recognize that improving engagement is a powerful tool to get the best out of your employees. An engaging workplace environment fosters creativity, encourages innovation, and, maybe most importantly, increases commitment. Workplace studies and trend analyses identify key elements that contribute to building an engaged and satisfied workforce.

This white paper investigates the important effects that lighting can have on the user (employee) within the office trinity: user, organization, and building. Our insights are supported with findings from the scientific literature to define the role that lighting can play in creating engaging environments that support productive organizations.



Focus on health and well-being

Desk work is such a basic part of contemporary human life that it's hard to imagine a time before business offices existed. But it wasn't until the about the mid 1900s that office work as we know it today became common.

Early offices were designed to handle the steady increase in administrative tasks that the industrial era made necessary. These were often large open areas filled with rows of desks, in which workers operated in a manner similar to their counterparts on mass production lines.

The knowledge economy, which started to emerge at the end of the 20th century, changed all that. Workforce efficiency by any means was no longer the only, or even the most important, consideration. Worker comfort was seen as just as important, based on the realization that output *quality* was more important than output *quantity*.

With these changes occurring in businesses across the board and around the world, innovative office design became a priority, ushering in the age of workplace consultancy. The result has been a number of different office concepts and design strategies that move workspaces away from traditional cell offices and cube

farms and toward collaborative and flexible approaches intended to foster communication and creativity.

So what are these design strategies, and how do they influence offices today? Some strategies, such as New Ways of Working (NWoW), originally developed by Dutch architect Erik Veldhoen in the 1990s, focus on the way organizations work—the type of work being done in a workspace, the type of people who work there, and the specific activities that they perform. Concepts such as Activity Based Working and agile working share this focus. Strategies including biophilic design and building certifications like the WELL building standard, in contrast, emphasize the health and well-being of office users.

Every office is unique in the way it addresses specific user needs, organizational requirements, and brand profiles. But the underlying design concepts often link back to a few key strategies, and always with the same end goal in mind: creating the best possible environment in which both the company and its employees can thrive.

The office trinity

Offices pose interesting challenges for designers. There are often many stakeholders to consider—office management and office occupants, at a minimum—as well as aspects such as human interaction patterns and social behavior that may be more difficult to define. Office cost models reflect this complexity. According to the World Green Building Council (WGBC), ^[1] approximately 1% of organizational spending goes toward utility costs (electricity, water, and so on), 9% toward real estate costs, and the remaining 90% toward employee costs. Clearly, organizations seeking ways to lower costs must look beyond energy savings and focus on employee and real estate spending, where space optimization can have a significant impact.

As part of our WorkingPeopleLight project, we developed the “office trinity,” a model to facilitate the discussion around innovation in office design. The office trinity defines three elements in the office ecosystem: the user, the organization, and the building.



Designing for the user

All design decisions revolve around the needs and desires of the user. Design concepts are intended to reduce employees' physical and mental stress, improve their overall mood, and offer them autonomy and choice. Recent studies by Leesman, Steelcase, and The Stoddart Review emphasize the importance of engagement and workplace satisfaction in creating a productive workforce.^[2–4]



Designing for the organization

Design decisions focus on the needs of the organization, taking into account organizational dynamics such as types of work being performed in a space, space utilization, employee interactions, and management style. Different office layouts are developed to satisfy the requirements of specific tasks in different kinds of environments. As with Activity Based Working, designing for the organization must go hand-in-hand with designing for the user.



Designing for the building

Good building design optimizes space, creates a sustainable footprint, lowers maintenance needs, and minimizes environmental impact. While not necessarily an enabler for employee engagement on its own, good building design can contribute significantly to employee satisfaction and company culture, resulting in increased engagement.



Making the environment engaging and satisfying

Creating an environment with the right fit for the organization and users requires looking beyond cosmetics and interior design. It requires an in-depth analysis of the DNA of the organization and a clear understanding of its goals. What kind of people does the organization want to attract and retain, and what should the corporate culture be like?

According to the workplace report published by Steelcase, “CEOs of leading organizations recognize employee engagement is one of the most critical metrics for businesses today and that it has significant bottom-line implications.” Worryingly, however, the report finds that about 37% of the average workforce is disengaged. ^[4] Additional key findings from the Steelcase report indicate that workplace design has an impact on the satisfaction of employees and that workplace satisfaction and employee comfort levels positively correlate with employee engagement. ^[4, 5, 6] This shows that high user comfort can potentially reduce turnover rates, and highlights the need for more data on space utilization and employee satisfaction.

Office designs must ensure that the environment attracts the best of the best and retains them by delivering the highest level of comfort and quality. The office environment, in short, must be designed to foster engagement.

It is well known that the environment plays a large role in determining employee experience of the workplace, and has a significant effect on employee well-being. These effects are not limited to the visible elements of an environment (furniture, decoration, layout, and so on), but also to environmental factors such as sound, temperature,

and air quality. A study by Leesman ^[2] indicates that 88% of employees rank desks as the most important feature in an office, and 86% rank chairs as the second most important. Noise levels ranked sixth, with 74% of employees finding it important. However, 71% of the people who flagged desks as important are satisfied with the desks that they have. On the other hand, only 30% of the people who ranked noise levels as important were satisfied with their current office conditions.

How does lighting contribute to the office atmosphere and how can it be best applied today? Standards provide recommendations to ensure comfortable lighting for visual tasks. But how can lighting address concentration, collaboration, happiness, and feelings of belonging? The following sections discuss how to use lighting to create the most engaging and satisfying work environment. Our recommendations are based on a thorough analysis of the findings in the scientific literature and a broad range of other insights on the role of lighting in increasing workplace satisfaction.

“CEOs of leading organizations recognize employee engagement is one of the most critical metrics for businesses today and that it has significant bottom-line implications.”

“Engagement and the Global Workplace” report, Steelcase



Lightscaping: shaping the environment with light

Lighting can powerfully influence the well-being of office employees, increase workplace satisfaction, and lead, at least indirectly, to improved employee engagement.^[5, 7–10] This fact is reflected in the growing popularity of healthy building certifications, where lighting often plays a prominent role. Approximately 10% of the features in the WELL Building Standard are directly linked to lighting, and an even larger percentage of features includes solutions involving lighting. Generally speaking, these features all relate to the three core ambitions of human-centric lighting (HCL): support people so that they see better, feel better, and function better.

To make the effects of lighting more tangible, the sections that follow consider how light affects different systems in the body: the visual system (light for sight), the emotional system (light for the heart), and the cognitive system (light for the mind).

Although we've tried to limit the following discussion to the first-level effects of lighting on the body (sight, heart, mind), it's important to keep in mind that most lighting conditions also have secondary or even tertiary effects. For example, poor visibility on the "see better" dimension often causes negative emotional responses in the "feel better" dimension and can even result in stress that has negative effects in the "function better" dimension.

Because all three dimensions are interdependent, efforts to influence one almost always influences the other two as well, either positively or negatively. When raising light levels to ensure visual performance, for example, you should avoid creating an overly bright environment, which can negatively affect light for sight (glare) and light for the heart (especially if you want to create a comfortable and informal atmosphere).



Light for the heart

Light for the heart helps us to feel better, and supports our preferences and need for autonomy. This is done by examining lighting effects (or aspects of lighting installations) that trigger emotional responses.



Light for sight

Light for sight helps us to see better. This means being able to comfortably perform visual tasks (such as reading) by improving the legibility of the task (such as text on paper), but also by minimizing sources of eye stress (such as glare).



Light for the mind

Light for the mind helps us to function and perform better by investigating how lighting influences our Circadian rhythm and hormonal systems, and how it can help improve concentration and ensure a healthy sleep-wake cycle.



Light for the heart

We often take the effects of light for granted. This is usually due to a limited understanding of how light influences our mood and behavior. Indeed, building occupants tend to overlook the effects of lighting, often attributing the quality of their workplace experience to interior design and the type of work they have to do (furniture, computers) instead. For example, most people will characterize a poorly and dimly lit office as unappealing or less lively ^[11] without necessarily recognizing the role that lighting plays in creating such an atmosphere. The numerous and significant effects of lighting on behavior, mood, satisfaction, and comfort are well supported by scientific findings. ^[12-14] For this reason, it's essential to assess not only the objective facts such as light level and quality, but also how light makes us feel. This is light for the heart.

Lighting has been shown to impact several behaviors that are typical in office work. Lighting affects interpersonal conflict and how people judge each other. ^[15] Bright light positively impacts quarrelsome behavior, such as arguments between colleagues, ^[16] and stimulates discussion. ^[17] The positive relationship between lighting and mood in general has been studied extensively, ^[8, 12, 18-21] with diverse underlying causes of these effects.

Several studies connect the subjective brightness of a room to how satisfied users are with their workspace. ^[12, 22-25] Color temperature is shown to affect users' mood, sleepiness, and light perception. ^[20, 26] Other studies indicate that the ability to control the lighting in an office environment enhances employee comfort. ^[27, 28] Research by Signify and the Eindhoven University of Technology also validates that the ability to control the lighting increases the perceived lighting quality. ^[29]

Personal control warrants further consideration. It encourages a sense of autonomy and also enables individuals to tune lighting conditions to meet their personal preferences. ^[30-32] Both of these benefits can have a significant effect on satisfaction, as they influence our natural desires for control and personal choice. Personal lighting preferences can include illuminance levels, color temperature, lighting type, and the lighting dynamics. As shown by various studies, personal preferences are quite diverse, making it challenging, if not impossible, to offer one lighting experience that meets all needs. ^[33] Current developments in connected office technology allow users to easily configure their preferred lighting conditions. Data collection and analysis promise to help identify the range of preferences in a specific workspace, enabling semi-automatic systems that provide preferred lighting.

It's useful to take a look at several important lighting parameters to indicate directions for lighting designs, either as fixed settings or as a range of settings for personal control applications. These parameters include light level, perceived brightness of vertical surfaces and ceiling, correlated color temperature, type of lighting fixture, and dynamics.



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Light level (illuminance) variation is the most well-known form of adjustable lighting. Studies have shown that preferred light levels depend on various aspects of the environment, including type of control, daylight availability, activities performed, dimming direction, and reference point. A majority of users tend to prefer higher illuminance levels for more demanding tasks, ^[13, 34, 35] while lower levels are more relaxing for the eyes. ^[29] Illuminance control is often intended to increase the task visibility, but in practice

it is often used to set the room brightness at a comfortable level.

Perceived brightness is mainly influenced by lighting in the visual field. The visual field is usually dominated by vertical surfaces in small to mid-sized spaces, while the ceiling dominates more in large office spaces.^[23, 36, 37] Vertical surfaces and ceilings are often not lit on purpose, but instead are lit by reflections from the lit horizontal plane (task areas). Lighting installations that are optimized for horizontal illuminance are far from ideal for creating bright and energetic spaces. Our studies with the Eindhoven University of Technology, which investigated the relationship between room brightness and variable horizontal illuminance, support this conclusion. Individuals tend to select lower task illuminances when the non-uniform wall luminance is high, and higher task illuminances when wall luminance is lower. These findings demonstrate the need for considering horizontal and vertical light levels separately.^[38]

Correlated color temperature (CCT) is another aspect of lighting often linked to personal preference. Many studies have indicated a link between CCT and biological effects, but CCT also has a large effect on the impression that a space makes. Cool color temperatures (for example, 6500 K) are often perceived as more bright, but are not always appreciated as they tend to appear more bluish and formal.^[39]

The environmental context, however, plays a major role. A cool color temperature can make certain spaces look modern (positive impact), but it can also make a hospital environment look sterile, cold, and formal (negative impact). The activity context also plays a role, and various studies show that different CCTs are preferred for different activities.^[40–42]

Along with illuminance, the type of luminaire—recessed, suspended, skylights, and so on—has a significant impact on

the appearance of a space, both in terms of their physical appearance and way they distribute light in a space.

Recessed luminaires tend to direct light toward a horizontal surface (a desk, for example), whereas suspended luminaires usually distribute light both downward and upward, creating a brighter ceiling. Light reflects off the ceiling to make the walls appear brighter. Several studies found that people often express a preference for this type of lighting over direct lighting only.^[18, 43, 44] Other studies found that desk lamps improved worker satisfaction and mood.^[45] This improvement may result in part from added personal control.

From an evolutionary perspective, human beings prefer daylight. This preference has to do with more than typical or average light level and color temperature. It also has to do with the dynamic nature of daylight due to the angle of the sun (time of day or year), cloud cover, and other changing conditions. Daylight is never the same, and when we're indoors, it links us to the outside world as well as to the weather and the seasons. Multiple studies indicate that people often prefer dynamic lighting scenarios over static lighting scenarios.^[46–49] It is unclear if this preference is based on changes in color temperature, changes in illuminance, or a combination.

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Light for sight

Without light, there is no sight. It's as simple as that! But what happens when there *is* light? Is even the slightest bit of light sufficient? The right light depends on the context and the task at hand.

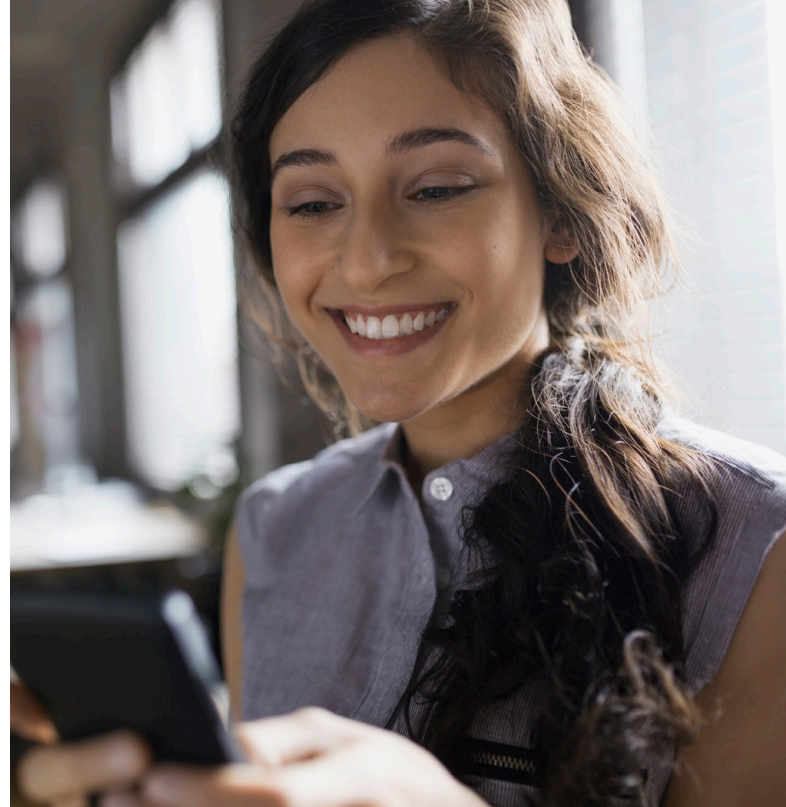
The eye is a very flexible and versatile organ. It can adjust relatively quickly to most lighting conditions. Given time, we can see even in the lowest light, when the eye “switches” from the highly accurate color-sensitive cones (photopic vision) to the less precise but more light sensitive rods which we need for night vision. Unfortunately, this trade-off comes with a cost. At low light levels, our eyes need to work harder to perceive differences, the ability to distinguish colors radically diminishes and we lose accuracy on the periphery of our field of view.

There are several issues to consider at higher light levels as well. Light levels in offices fall well within the range of photopic vision, so people can distinguish colors and see accurately. However, some tasks may require light levels above the levels specified in most standards to sustain performance over a period of time, especially if the tasks involve small objects or type.

Another potential issue is aging. Although “elderly” often refers to people age 65 or older, the eye already starts to deteriorate around age 45. ^[50] This means that approximately 34% of the potential working population ^[51] is already facing reduced vision and would benefit from higher light levels to compensate. Research conducted by Signify confirms that this is the case, and that visual acuity can be as much 36% lower for this group. Consequently, older individuals need more light to see the same level of detail and enjoy the same level of comfort. The CIE's report on vision in aging populations recommends light levels up to twice the minimum required by current standards, to compensate as much as possible for degraded visual performance.

If light levels are too low for a given task or to account for personal characteristics such as age, the eyes become tired more quickly, sometimes resulting in a burning sensation and headaches. ^[52] Interestingly, these symptoms are often wrongly attributed to the task itself, as with a computer task, for example. Lengthy screen usage is often part of the cause, but the discomfort is caused primarily by an overly bright display against a dark background. That is, light levels around the screen are too low compared to the brightness of the screen. Studies have found that background luminance should be similar to or slightly lower than the screen luminance in general (often around 100 cd/m2.) ^[34, 53, 54]

As discussed above, our visual, emotional, and biological systems interact with each other. Visual comfort is an environmental factor that can influence how an employee feels. People who report eyestrain—one of the consequences of visual discomfort—also report more physical discomfort and are less productive. ^[55] Other



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conditions associated with visual discomfort are red, sore, itchy, watering eyes; headaches; migraine attacks; gastrointestinal problems; and aches and pains associated with poor posture. ^[56] In this way, persistent visual discomfort can lead to increased employee absence.

Proper lighting design is not simply about absolute values, but about the proper balance of light and dark. Contrast should be controlled. Because glare adversely affects job performance, ^[57] overly bright light sources (as compared with the surrounding illuminance) should also be controlled. Standards such as the European standard EN12464-1 for light planning in workplaces provide some guidance. But they typically provide minimum target levels only. To ensure that your lighting supports your goal of maintaining a satisfied and engaged workforce, you need to go beyond the targets indicated in these standards.

Light for the mind

Seeing well and feeling well are paramount for productivity in the workplace, and numerous studies have shown how light can enhance and improve employee performance.^[12, 44] We now have experimentally verified evidence that light affects our physiological functioning. For example, workplace lighting can have a measurable effect on employee alertness and concentration. Several studies found improvements in alertness when using light levels of 1,000 lux.^[58-62] Other studies found that exposure to certain levels of light led to increased performance on specific tasks, such as faster response times, less time needed to complete a task, and better long-term memory recall.^[60, 63, 64] Lighting exposure also affects our sleep patterns. A healthy sleep-wake cycle allows us to be productive during the day and have a high quality of sleep during the night,^[59, 65, 66] both of which help to maintain a healthy, satisfied, and engaged workforce.

How does light affect physiological functioning? In addition to rods and cones, our eyes contain a third type of receptor called the intrinsic photoreceptive retinal ganglion cell, or ipRGC. While the rods and cones provide a visual pathway for light to affect human functioning, ipRGC receptors influence the so-called non-visual pathway. The ipRGC receptor is the primary input, or *zeitgeber*, of the body clock, which resets our body to ensure we maintain a healthy 24-hour sleep-wake cycle, or *circadian rhythm*. Exposure to light suppresses the body's level of melatonin, the sleep hormone, to ensure that we are awake during the day. The absence of light at night increases melatonin levels, so that you can rest at the right time.

But why do we need a reset in the first place? Doesn't the human body follow the 24-hour cycle automatically? Actually, not quite: without sufficient exposure to light, the human body follows a cycle of 24.5 hours. That means

that the body completes its cycle 30 minutes later each day, leading to eventual desynchronization. Because our working hours do not shift daily, we need reset methods to ensure that the body stays on the proper 24-hour cycle.

Studies have indicated that the right lighting can be an effective reset method. The Healwell studies conducted by Signify and the University of Maastricht demonstrated that the right lighting improved the sleep duration of patients (with the intention of thereby improving recovery times).^[67] Other studies have shown that a healthy sleep-wake pattern can lead to improved vitality and reduced depressive symptoms.^[21, 68] These improvements in turn may reduce the amount of sick leave that employees take, in addition to lighting quality, which has already been linked directly to reductions in employee sick leave.^[9]

Light for the mind is not limited to biological effects alone. As shown in a study we conducted with the Eindhoven University of Technology, perceptions of the room itself can also trigger relevant effects.^[69] The wall luminance of an office space, for example, affected subjective alertness which affects our functioning. Additionally, as we already saw in the section on light for the heart, lighting can also have an impact on specific behaviors and types of activities. Various studies have shown that lighting can have an impact on discussions and intimate communication,^[70] creative performance,^[71] and conflict resolution.^[72] Environmental stress caused by an inadequate indoor environment can reduce motivation, negatively affecting cognitive capacity for work and rate of work.^[73]



Conclusion

Balancing the requirements of user, organization, and building, while ensuring that lighting meets the requirements of heart, mind, and sight, is no easy task. These requirements often overlap, but there's no guarantee that the design decisions that satisfy them will work well together. A cool color temperature might benefit a user's mood, but it may not create the atmosphere that either the user or the organization prefers.

Lighting is a powerful tool, but it must always go hand in hand with other elements of office design, including environment (sound, air, temperature), interior (furniture, size and structure of workspaces, color schemes), office layout (floorplan, flexibility, support for specific tasks and collaboration), and facilities. Design strategies such as New Ways of Working and Activity Based Working offer some good examples of how to design dedicated spaces to support conflicting needs and different activities in the same building.

Connected lighting is crucial for guaranteeing comfort in these flexible spaces, allowing fine-tuning of atmosphere and lighting conditions, dynamics, flexibility and personalization, and data-driven capabilities such as resource finding and space optimization.

Offices must be designed to satisfy the needs and desires of the employees who use them for many different and sometimes conflicting purposes—whether focused activity in meeting rooms or booths, collaboration in open office spaces, or more informal brainstorming sessions in breakout rooms and communal areas. Optimizing the workplace experience and creating an engaging environment is key to enabling a highly productive workforce. Lighting designs and systems for offices must therefore balance all of the different aspects discussed: light for sight, light for the mind, and light for the heart.

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About the authors



Adrie de Vries

Adrie de Vries holds a master's degree in Building Physics from the Eindhoven University of Technology, faculty of Architecture Building and Planning. After graduating on the topic of the effects of (day)light on the performance of office users in 2008, he worked as a lighting consultant and designer for several years at the regional office of Royal Philips in the Netherlands. This was followed by several years in a consultancy role, supporting Philips product development in identifying the lighting and product requirements for the office product portfolio.

As of 2017, Adrie started working in the Research branch of Signify (formerly known as Philips Lighting) focusing his efforts on the effects of lighting on office workers and developing new propositions around these effects. This is combined with a PhD track in the field of environmental psychology at the Eindhoven university of Technology, Human Technology Interaction group.

Adrie is active in several standardization bodies working on global and European standards involving lighting design and workplace requirements (CIE, ISO, CEN).



Sanae van der Vleuten-Chraibi

Sanae van der Vleuten-Chraibi, received her bachelor's and master's degree in architecture building and Planning at the Eindhoven University of Technology, with the master specialization program Physics of the Built Environment. In 2011, she graduated on the topic of visual comfort in office environments. She started her professional career with an assignment for TNO, exploring user comfort with adaptive energy-efficient facades. At the end of 2011, she joined the Research department User Experience and Interaction of Royal Philips B.V. In 2012 Sanae worked as a visiting researcher at Philips North America, conducting user experience research for multiple lighting projects.

Since 2014, Sanae has been employed by Signify, focusing her research work on the user experience of lighting. Coordinating and conducting research activities in which user needs and experiences are explored, Sanae has been involved in several projects, with the role of lighting in user well-being and satisfaction in offices as a central topic. In 2019 she will finalize her PhD thesis presenting research addressing employee well-being through personal control of lighting in multi-user office environments.

In addition to her activities for the Office segment, Sanae has led scenario planning activities for different domains, including scenarios on Offices, Future of Living, and Future of City Experiences. The scenarios are used to stress-test research programs and business strategies, and as input for future-proof propositions.

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