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Master-Thesis

Mimicking Day Lighting in Office Spaces

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Submitted by: *Poorvi S. Kamath*
Born *26.02.1991*
Master Architectural lighting and design management,

First Mentor: Prof. Dr.-ING.Harald Hofmann
Second Mentor: Prof. Dr.-ING.Thomas Romhild

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Mimicking Day Lighting in Office Spaces

Poorvi Kamath

Wismar institute of Design Science and Management

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Abstract

Mimicking Day lighting in office Spaces

This paper points out the fundamental need for efficient office lighting. If one considers the amount of time spent in indoor offices by an average adult, office lighting needs more than just meeting appropriate lux levels to work through the day. This paper attempts to understand the various factors coming into play on a regular office workday in order to determine the best way to mimic daylight in office spaces. The literature analysis in this paper is broken down into two parts - first is to understand the concept of daylight and its benefits and the second part is understanding the functions and working of an office and the principles for office lighting.

The broader field of study is Human Centric Design. This research is aimed to inform the design community of the different ways and techniques for creating sufficient comfort to the human eyes and minds in an office space using artificial light. Different techniques are considered in order to achieve this result including mimicking the different characteristics of daylighting independently with the aim to deceive the human mind into believing the existence of daylight in an environment that has little or none.

The office spaces considered in this paper are those which lie further away from windows or lack a good source of diffused light. Most often, the deeper spaces in an office layout do not receive sufficient daylighting. Several countries in Europe require an employee to be working not more than 27ft away from a window. However the reality of this matter is different. Not to forget the countries that do not receive sufficient sunlight over long periods of time, where mimicking daylight solutions need to be considered.

This thesis is based on the standpoint of daylight being the best kind of light for living beings. The question of my thesis is if there are ways to mimic daylight by using artificial light. Using scaled models, the possibility of mimicking a skylight with artificial lighting was tested and later surveyed. A self-administered questionnaire was used as the testing instrument to understand general opinion of a set of random office workers. The results showed that a majority of people were not able to differentiate between a skylight and an imitated skylight.

This gives hope to a new approach in office lighting using daylight imitations.

Introduction

Experts agree that not just the presence, but also the quality of light affects our mental and physical health, including our overall performance at work. According to an article published in the National Human Activity Pattern survey of the USA, about 86% of an average American's time is spent indoors, mostly between their office and residence.(Bureau of Labor Statistics, 2015) These statistics shouldn't differ much from statistics of people working in urban spaces across the globe. For office workers the major part of their day is spent in spaces devoid of natural light, cooped up in compartments with mostly harsh artificial lighting.

When employees are subject to poor lighting they experience significant mental and physical health defects, this in turn creates a domino effect, impacting the efficiency, productivity and sales of the company. Working environments and the happiness quotient of the employees directly and indirectly impact the company's progress.(Silvester & Konstantinou, 2010) It is believed that natural daylight is key to creating satisfied and healthy workers and can offer numerous benefits; yet, for many companies, constructing green buildings from scratch or performing heavy retrofits on existing buildings is not financially viable. Moreover if buildings are designed to allow sufficient day lighting into the building, there is a limitation of height restrictions among multi-storey buildings and glare issues with horizontal fenestrations. To prevent a loss in productivity and to provide safety in the absence of daylight, the solution must be to provide workers with a source of artificial light that closely imitates the best qualities of daylight.

Despite massive developments in science and technology, we have not yet been able to fully replicate daylight or the benefits of the sun artificially. However, attempts to replicate certain

aspects of daylight such as UV rays, visible light, even the phenomenon of a skylight have been observed. By methods of analysing technological availability on the one hand and existing attempts at mimicking day lighting and drawing inspiration from the architectural possibilities of day lighting on the other, this thesis led me to build models to understand the possibility for alternate solutions.

Limitations of the Study

The limitation of the research is the inability to conduct live experiments on behaviours and construct mockups. Furthermore, tests would be needed over a period of weeks/months to determine the feasibility. The research for this thesis is conducted by scaled models and survey questionnaires, which also pose limitations due to the subjectivity in the perception of daylight as it is understood that the quality of sunlight and daylight differ across the globe, so does the expectation of daylight. The color and intensity of daylight along with the position of the sun varies across the latitudes and altitudes of the geographical location. People brought up in a certain geographical location may experience a shock when relocated to a location with unfamiliar daylight intensity. For example a person in a tropical setup would see light very differently from a person from the Nordic region. Sensitivity to sunlight and the threshold of vision of the eye changes with age. This brings about variation in human choices. Light being extremely subjective, it makes it almost impossible to be precise about the impact it has on people.

Acknowledgement

I am very thankful to be presenting the Thesis as a student of Wismar University. I thank the university and our student coordinator for having supported me through this thesis topic. A heartfelt thanks to all my professors who have, in the last two years taught me everything they have about lighting and the profession. I am especially thankful to my mentors Prof. Herald Hoffman and Prof Thoman Rhomild for showing immense interest in my thesis and guiding me with their encouraging words and valuable criticism.

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1.0 LITERATURE REVIEW (Part 1)

1.1 Daylight

When sunrays hit the earth's atmosphere, they go through various atmospheric layers of reflection, dispersion, refraction and transmission to reach the surface of earth as DAYLIGHT.

The suns packets of electromagnetic energy are quantified in wavelengths and frequency. A measure of wavelength is defined as the distance between two successive peaks or troughs in waves of energy, while frequency is measured by counting the number of peaks that pass a given point every second. The suns radiation can be broken down broadly into three components: visible light, with wavelengths between 400nm and 720nm, Ultraviolet light and wavelengths shorter than 400nm, and infrared radiation, with wavelengths longer than 720nm. A part of this spectrum is lost in the earth's higher atmospheric strata and most of them are transmitted (roughly 75%). (Wolff, 2012)

Furthermore the sunlight experienced at the earth's surface can be classified into two kinds, which are direct sunlight and diffused light. While direct sunlight is that of direct rays from the sun, diffused light is that which is dispersed from atmospheric particles. When we talk about daylight inside a building, there is also the element of reflected light. The light reflected from the neighbouring buildings and also by immediate surfaces around us. Different surfaces have varying surface reflectance properties depending on the color and texture.

The chromaticity[1] of daylight varies across the latitude and altitudes, and/or furthermore it varies through the seasons of the year. While the extreme latitudes receive a more blue rich

[1] Chromaticity-The quality of colour, independent of brightness

white light, the central belts receive a reddish rich chromaticity in daylight. (Johann, Solveig, Jorgen, & Ragnar, 2004)

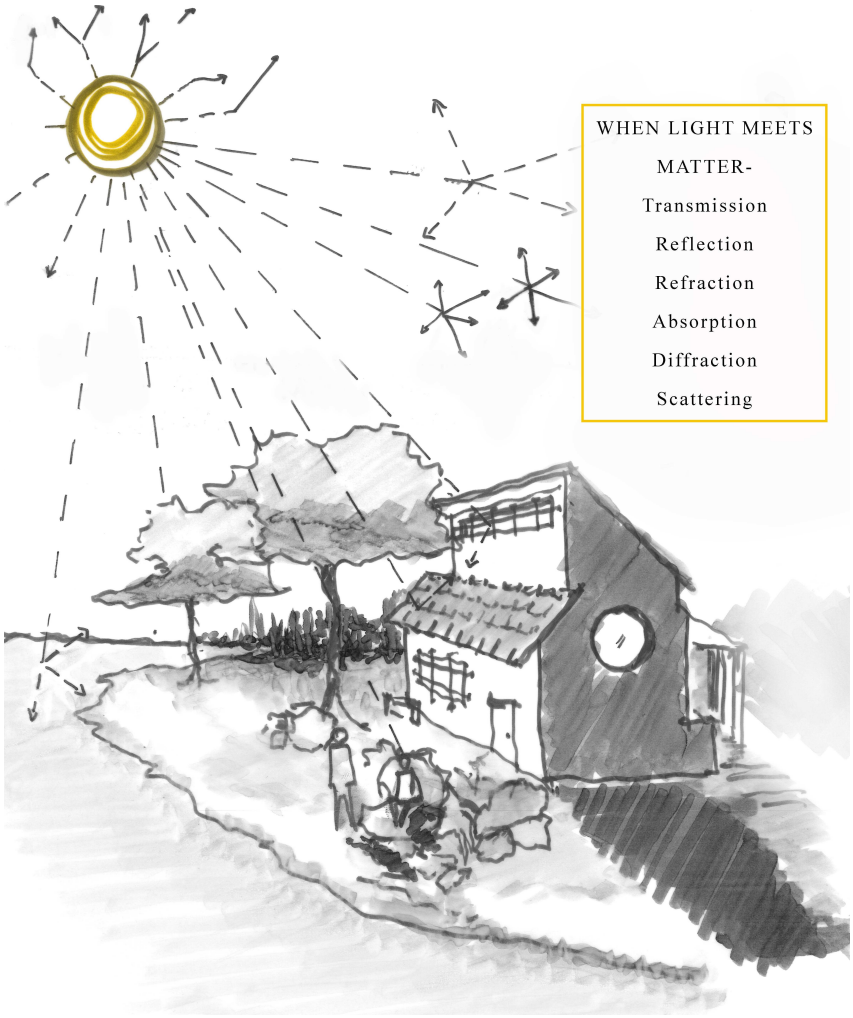


Fig.1 Different stages of sun's rays.

The period of transmission of daylight is commonly referred to as daytime. Due to the rotation and revolutions of the earth, daylight is considered to be constantly dynamic which changes through the 24 hours of the day and the 12 months of the year. On the other hand, moons light is not considered daylight since the moon only reflects the light from the sun and this reflection takes place outside the earth's atmosphere.

Sunlight is one of the primary sources of energy for sustenance of life on planet earth. All life on earth requires daylight for growth and survival. Besides the greater influence of sunlight on living beings, the influence of daylighting on human wellbeing can be broken down into

the following categories:

1) Visual Impacts

Visual performance is the ability for one to see objects and perform tasks. The ability to see accounts for one of the five senses which characterize human beings. This is also the primary function of daylighting in a space. However the quantity of the lighting required for a task is subject to the lighting levels in the surrounding. Depending on the task in question, the contrast of task area to the surrounding is more important than the independent measure of light at task level. For E.g. As per most standards, the task area is required to be a couple of 100 lux brighter than the immediate surrounding. The minimum requirement at task level varies between 300lux to 700lux depending on the part of the world and the ratio between immediate surrounding and task levels is around 1:1.5 or 1:2

Older people generally need more light to read and perform tasks as compared to somebody 20 years younger. Visual performance is dependent on age and eyesight.

Spatial recognition is the appearance of a space with day lighting. Architects use this concept to manipulate perspective and the reality of the space. This maybe used to the advantage of the architect to cleverly carve out positive and negative spaces. A volume of space feels and seems different with daylight as compared to artificial lighting. A space may seem taller, wider, bigger or deeper depending on the placement of openings in the space regardless of the contextual internal décor of the space. Also, when a space has a higher reflectance or is painted a lighter colour, light tends to bounce off at a higher rate making the space seem bigger as compared to a space with lesser light.

Stress and restoration; Besides providing daylighting for vision and three-dimensional rendering, fenestrations provide an opening to view the outside. Psychologists have studied this impact for several years. Experiments show a faster recovery of patients in hospitals with

a view of a green outdoor as compared to patients cooped up in windowless spaces.(Edward & Torcellini, 2002)Windows or skylights provide a sense of connection with the outside and the ability to gauge the weather outside informs one of the real setting.

2) Non-Visual Impacts

Apart from the obvious image forming properties of light in the human eye, light also triggers signals to the brain and the hormonal system to perform other functions. In 2001, the discovery of intrinsically photoreceptive retinal ganglion cells in the melanopsin in the eye has led to new research in the field of light and its impact on the human physiology and psychology.(Cajochen, et al., 2009)

Circadian regulation is an endogenous timing system that guides the physiological changes and behaviour in the human body. It is understood to be a 24-hour biological rhythm, which has evolved to be in sync with the earth's rotation or in other words, exposure to the sun. The release of the sleep and wake hormone is predominantly controlled by the Circadian regulation.(Cajochen, et al., 2009). Thus it is safe to say that light has a considerable impact on the human circadian rhythm or the 24-hour sleep/wake cycle. Melatonin, which is commonly known as the sleep hormone is known to peak in darkness and drop with the exposure to daylight. The release of melatonin initiates all the nocturnal activities that take place in the body along with dropping the core temperature of the body. Several cells in the body contain melanopsin and the ones in the human eye containing them are called ipRGC (intrinsically photosensitive retinal ganglion cells), which are known to be most sensitive at blue wavelengths of light. ipRGC are a type of neuron in the retina of the mammalian eye. These show to be a special type of retinal ganglion cell, which, unlike other retinal ganglion cells, is intrinsically photosensitive. They are a class of retinal photoreceptors, excited by light even when all influences from the better known photoreceptors

(rods and cones) are blocked (either by applying pharmacological agents or by dissociating the ganglion cell from the retina). Photosensitive ganglion cells contain the photo pigment melanopsin of the primate retina and are examples of photosensitive ganglion cells As per research, the exposure to sunlight in the mornings is supposed to suppress the melatonin release and increase alertness. (Cajochen, et al., 2009)

Mood alertness and Cognition; Human alertness is sensitive to the light exposed to in the daytime as well as nighttime. A 2006 research on impact of light exposure on brain activity suggests that there is a dynamic variation in brain activity in relation to the variants of intensity and wavelength of light exposed to the human subject. These effects however do not impact any visual image formation but the alertness, mood and hence cognition. The results were studied by magnetic resonance imaging, which showed a remarkable dynamism in the response to light. This shows a direct relationship to human performance with full spectrum white light. (Vandewalle, et al., 2006)

3) Physical Health Impacts

Thermal Sensation; Windows cause both thermal gains and heat loss, and both those factors influence the comfort of the people inside, depending on the numerous physical variables like the time of the day, climate, façade orientation, and use of internal or external shades. These physical variables would be expected to influence the conditions inside the building in predictable ways from physics and engineering models.

Source of Vitamin D; It is known that electromagnetic radiation penetrates skin, for example, infrared wavelengths give rise to the sensation of warmth. The most physiologically influential wavelengths are the very short wavelengths of the ultra-violet which range from 280 nm to 380 nm. Skin absorption of ultra-violet radiation initiates several biological processes. Part of this spectral range causes adverse consequences like as sunburn, the

genetic changes leading to skin cancers, and premature aging (Juzeniene et al., 2011; Webb, 2006) and the other results in the production of a necessary pheromone, Vitamin D. Vitamin D synthesis in the skin occurs in reaction to ultra-violet radiation exposure in the range of (280-315 nm) (Juzeniene, et al., 2011; Webb, 2006). Vitamin D has long been known to regulate calcium absorption and to maintain strong bones and teeth (DeLuca, 2004), and in recent years it has been connected to immune regulation (Hayes, Nashold, Spach, & Pedersen, 2003), cardiovascular disease (Zittermann & Gummert, 2010), and mental health (Humble, 2010) and implicated in the etiology of cancers (Grant, 2010) and auto-immune diseases such as multiple sclerosis (Kampman & Steffensen, 2010). Of the ultraviolet radiation that reaches the Earth's surface, more than 95% is the longer wavelengths of UVA, with the small remainder UVB. There is essentially no UVC. (Epstein & Wang, 2013). UVA is known penetrate skin more deeply than UVB and is known to play a major part in skin damage and aging. UVB on the other hand damages skin at the superficial epidermal layer. It plays a key role in the development of skin cancer and a contributing role-play in tanning and photoaging. It is important to take note that most daylight glazing have a UV protected layer, which filters out most of UVB radiations. Clear glass allows up to 75% of UVA to pass. Tinted and reflective glass absorbs more of the UVA but still allows about 25-50% to pass.(Sackey, et al., 2015) With the publication of a new report by the CIE, recommending that public health authorities develop recommendations and models for minimum levels of UV exposure to promote good health (CIE, 2011c), it is safe to say that there will soon be suggestions that this exposure be provided through interior lighting, either electric or daylight. The aim is to achieve an adequate level of circulating vitamin D by the way of exposure to UVB radiation while avoiding dangerous exposure to both UVB and UVA radiation (the latter being in the range of 315-380 nm).

1.2 Characteristics of Daylight

The sun is the most important source of energy and is predicted to be the biggest source of renewable energy by 2050. On an average 44% of the radiation accounts for visible light and 4% UV radiation while the rest is Infra Red radiation. The atmospheric strata blocks about 77% of the UV radiations. Daylight is the range of wavelength between 380nm to 740nm, which are visible to human eye. (Sunlight, 2016)

The characteristics of daylight are as follows -

Daylight is Dynamic

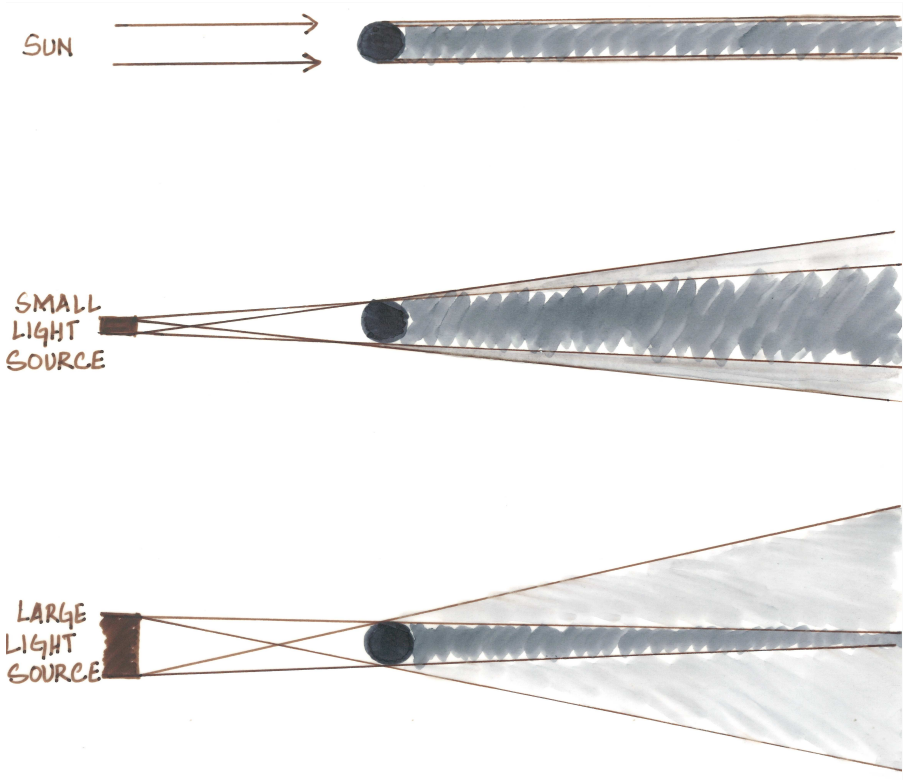
At any given geographical coordinate on the planet, the physical direction of the sun's rays change through the course of the day due to the rotation of the earth. The dynamism of the sky and the moving atmospheric particles also contribute to the variable daylight. The spectral compositions of daylight also shift through the day, as well as through the seasons of the year. The intensity of the radiations vary from dawn to dusk, so do they with the changing atmospheric activities throughout the year. The intensity of the radiation also differs geographically throughout the planet. The geographic coordinates in terms of the latitude and also the altitudes, of a given location play an important role in the analysis of daylight.

Rendering of Sunlight

The Sun as a light source produces direct parallel radiations of light and when the electromagnetic waves of sunlight travel through air particles and water particles, these light waves tend to get absorbed, reflected and/ or refracted depending on the nature of the particle. The magnetic field of the region also determines the play of light in the sky. The sky gives us this diffused and indirect light along with the direct parallel rays of the sun. Both behave very differently when they meet a surface.

Direct sunlight could produce an illuminance of 0- 100,000Lux with a colour temperature varying from 3000–1,000,000 K(Hernandez- Andres, Lee, & Romero, 1999). Its colour-rendering index is considered to be the best (100%) regardless of the time of the year and hour in the day. However, this kind of sunlight provides an uneven illumination and casts stark shadows. The angle of incidence of direct sunlight can be determined with the sunpath diagram.

Below is an illustration to show how a pole would cast shadows under three circumstances - of sunlight, a small light source and a bigger light source. When sunlight strikes, its parallel rays cast parallel shadows while the artificial sources induce acute/obtuse shadows. The two kinds of shadows created here are called the umbra (the dark shadow) and the penumbra (the lighter shadow). As you see, the shadow rendered by sunlight is far different from that of any artificial source. Image Below: Showing shadow cast by different light sources.



When considering direct sunlight for daylighting of offices or living spaces, it is most often unfavourable due to the high probability of glare and related visual comfort. Especially because offices in the present day use vertical computer screens for working which makes direct sunlight highly undesirable. It also causes thermal gain on buildings, which could result in excessive cooling load.

Diffused light is a derivative of direct sunlight, after it travels through the atmosphere. The diffusion varies according to the composition of the sky such as for example in cloudy/ overcast sky, foggy sky and clear sky, thus impacting the final quality of the diffused light reaching the ground. This kind of light causes a more even illumination indoor and is available throughout the day subject to the availability of sunlight. The intensity of diffused sunlight varies with the condition of the sky and the density of the different particles suspended in the atmosphere. **Diffused sunlight is the best light for day lighting and causes no glare to horizontal or vertical surfaces. It is the primary and desired source of day lighting.**

Reflected lighting from exterior surfaces like the neighbouring buildings is considered to be the secondary light source of day lighting. This forms an important criterion in daylight design for buildings, relevant to mostly vertical day lighting fenestrations.

Rhythm of Daylight

Daylight is responsible for sustenance of life on the planet. The rhythm of daylight/nightlight, the light/ darkness, the cycle of seasons are all components that support growth, life and death. Sunlight is the primary rhythm, which initiates numerous other rhythms of living and non-living things on the planet.

1.3 History of Day lighting in Architecture

Post industrialized architecture that we live and experience is far different from the pre-industrialized architecture. Ever since architecture existed as a form of science, day lighting has been a part and parcel of its making. As Le Corbusier once said

"The history of architecture is the history of struggle for light".– Le Corbusier

From the time of the earliest architecture, skylights were designed to suit the climate, availability of sunlight and the structure of the building. Since most of pre industrial architecture was built with load bearing walls, cutting out low-level windows like we have today was not the easiest of options.

PREINDUSTRIAL PERIOD

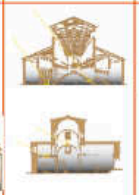
ANCIENT EGYPT	ANCIENT GREECE	ANCIENT ROME	EARLY CHRISTIAN	BYZANTINE	ROMANESQUE	GOTHIC	RENAISSANCE	BAROQUE
50th C B.C. - 1st C B.C.	8th C B.C. - 2nd C A.D.	2nd C B.C. - 4th C A.D.	A.D. 313 - 800	A.D. 330-1453	A.D. 800-1100	A.D. 1100 - 1600	A.D. 1400- 1830	A.D. 1575 - 1770
Clerestories Roof slits Small windows Doors	Clerestories Skylights Small windows Doorways	Clerestories Skylights Glazing	Clerestories Linear Perspective High level windows	Stained Glass Windows Play of perspective Semicircular headed openings	Clear glazing Rose windows Recessed openings Southern facing openings	Stained glass Southern facing openings	Vertical grouping of windows Semicircular or square-headed recessed openings	Play of light Play of perspective Recessed openings
								

Fig. 2 Table of Pre-industrial periods of architecture and character of daylight.(Cheochumba)

All the way from Roman and Greek architecture to renaissance and Baroque architecture, there was an extensive use of Clerestory windows which are used in various sizes in the different architectures. While in Egyptian architecture the size was limited to the size of the structural stones, in Romanesque architecture, the slopes under which the windows were placed guided the clerestory sizes. However, the architects responded to the climate and the availability of sunlight by manipulation of the sizes and strategic placement to their advantage. It seems like the architects of preindustrial time used day lighting to highlight certain spaces and objects selectively. This resulted in a high difference in light levels through the buildings. One would notice these lighting contrasts in the paintings of those times. The windows had a special prominence in the building, for Eg. In the design of the churches, the most sacred function of the altar or the ancient god's statue would be planned so as to receive the highest level of light as compared to the Nave and the Aisles. Function followed the light. (Chepchumba, 2013)

It is interesting to understand the way light was perceived back in the day. A well-lit space signified security, honesty and purity. The secondary form of lighting was only candles and oil lamps to support lighting in the interiors. The CCT or CRI of these light sources would be in reference to daylight due to the lack of artificial lighting.

During the world of industrialization and globalization, people learnt the usage of steel and glass. This was a huge development for architecture. The ability to support a building by a frame structure broke down several barriers in the field and gave architects a new kind of freedom. Also the availability of economical high strength steel and material prompted a lot of experiments in the field. When people started taking advantage of the new technology, they started replacing walls with windows. This introduced great potential in glare issues and

increased discomfort in user spaces along with winter heat loss and summer heat gain. However there were those few great masters of modern architecture like Le Corbusier, Lois Kahn, Alvaar Alto, F.L Wright, to name a few, who worked with this new technology using the ideologies of the past. Their design was site specific, creating contextual designs that were respectful of climate and orientation of site and building. (Chepchumba, 2013)

1.4 Architectural Analysis of using Daylight in Office

Daylighting as we know is a complex science due to overlap of several building construction disciplines like architecture, engineering, interior design and lighting design. However, today, the source of daylight can be broadly categorized into windows and ceiling fenestrations. Depending on the orientation of the windows and the sky, they either provide direct rays of sunlight or diffused sunlight when oriented on the side of the setting sun. Ceiling openings on the other hand if directly open to the sky (Fig. below), produce a stark highlight and shadow contrast, dynamic to the movement of the sun with an abundance of diffused sunlight. When the ceiling opening is designed with an indirect opening like in the monitor skylight, light from such a skylight will cast a minimal contrast with a good amount of diffused sunlight. In terms of good lighting for office, there is a need for abundance of diffused lighting more than direct sunrays, which most often distract, create glare and make it extremely difficult to perform any task.

In the image below, you will see that the domes skylight would allow more direct sunlight than the saw tooth, monitor and clerestory skylights. Depending on the depth of the overhang in the indirect skylights, the glare would decrease. The bigger the over hang, the ratio of direct to diffused sunlight would reduce. For an office space, it is more desirable to have skylights of deeper over hangs increase the diffused light ratio. A direct skylight would be suitable in spaces, which do not require sophisticated lighting. Direct sunlight would be used more frequently in residential buildings and spaces. In relevance to the applications today, saw tooth, monitor and clerestory openings are used to bring in the daylight element mostly in sheds and workshops where there are no height restriction.

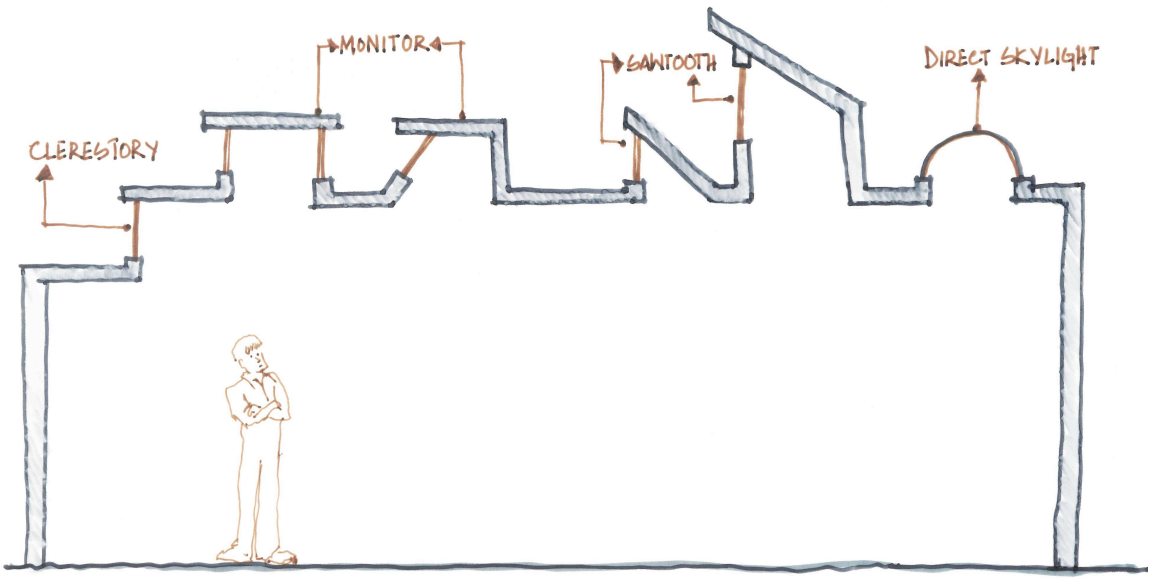


Image above: Direct and Indirect skylights

In situations where horizontal windows are used for daylighting, it would be a wise choice to use daylight control strategies. To a person sitting beside a window and working on the computer, it would be a challenging task to work, may it be a positive or a negative polarity[2] VDU display. Filtering harsh light is as important as letting the right light in. Daylighting shading devices range from overhangs, louvers, light shelves to mechanised shading structures programmed to the movement of the sun. Even simply planting vegetation outside would be a natural approach to sun shading. Different techniques work well in different situations. In illustration below, you also see light shelves which work well in re-directing light to the upper portion of the room to make the room brighter.

[2] Positive polarity – reading dark texts from light backgrounds and negative polarity- reading light texts from dark background.

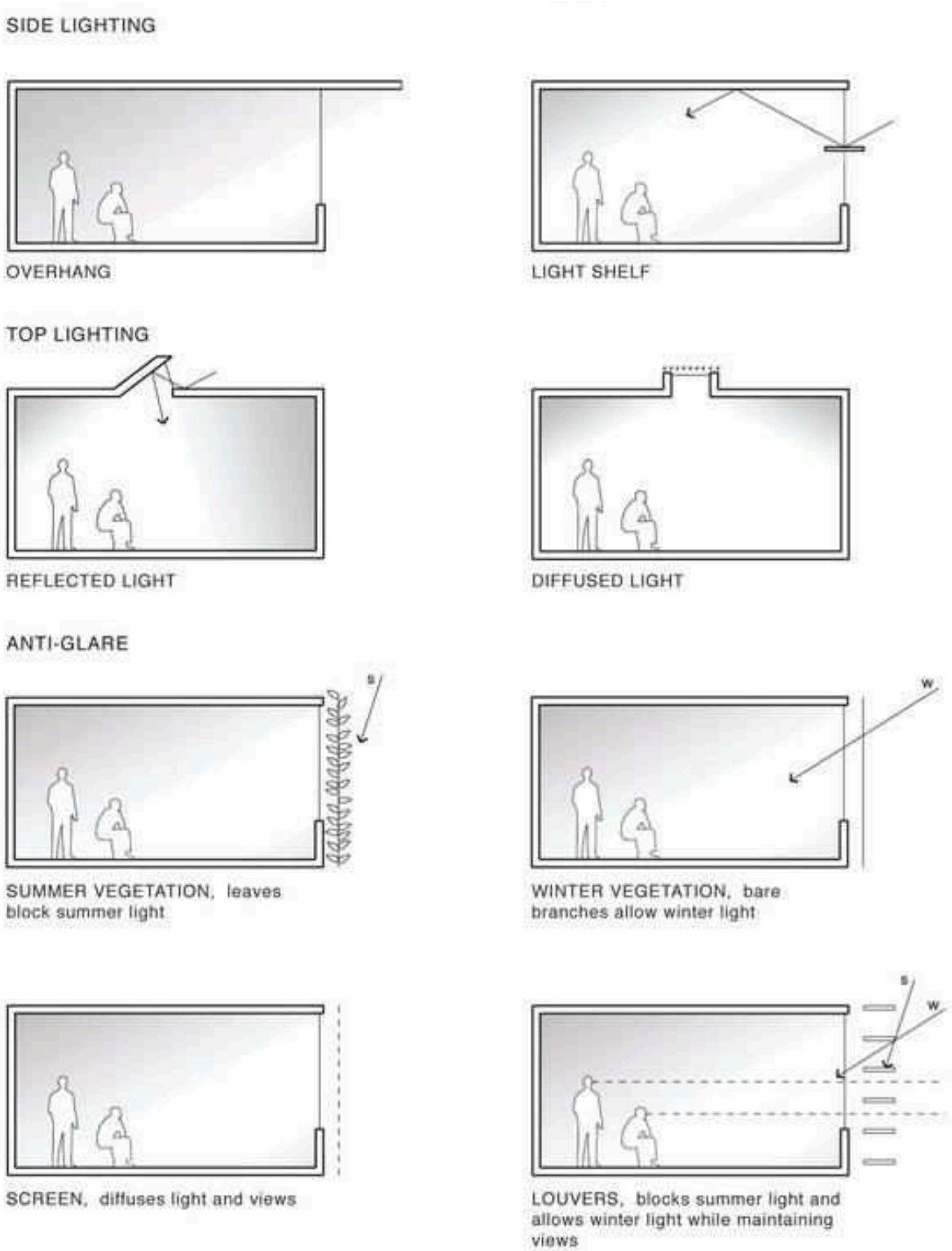


Image: Daylighting strategies (Tennessee)

2.0 LITERATURE REVIEW (Part 2)

2.1 Understanding an office space

In recent years office environments have undergone radical transformations. With swift advances in communication and information technologies, rapidly evolving corporate structures and totally new emerging forms of work. Today's offices are all about networks and computers, workflow and data exchange. This change in the way we work has a direct and indirect impact on other areas of our private and work lives. The society of the 21st Century needs different offices, suitably designed buildings and even new urban designs. The industrial kind of office work, where people drifted to their cellular offices in the morning and drifted back to their homes in the suburbs or city centre in the evening, is being replaced by new, personalized, flexible yet functional working arrangements. The traditional form of office work, where each employee performs one specific operation at his/her desk, has been replaced in many companies and organizations by more efficient and progressive forms of work such as project-oriented teamwork. Here, specialized team workers meet at various locations in various constellations for limited sessions of cooperation. Their primary office equipment consists of mobile phones, laptop computers and PDA (Personal Digital Assistant) and they decide for themselves where, when and with whom they work.

Flexible work timings and flexible work locations, non-territorial offices and mobile workstations need new architectural designs for offices to suitably accommodate these factors. Individual work is sometimes done at home or in a home office or within customers' premises, in combination offices or in a recreation zone. Company buildings are thus becoming communication centres for employees to meet and exchange information. Key facilities here are conference rooms, conference zones, cafeterias and studio spaces – places where teams can come together for formal or informal meetings. The "office building" system as a whole has thus become more complex. What is also interesting is that employers

are increasingly insisting that company buildings be designed to make a cohesive visual statement in chorus with the organization's corporate design. E.g. The Airbnb Head office in San Francisco, USA or the Google head office in California, USA. Starting from the façade to reception lobby, cellular office to combination office, executive office to open offices, there is a desire to suit every element of the company building to the organizations style and function. Above all, employees need a motivating, performance-enhancing office atmosphere**.** In short, the challenge lies in creating an ambience for work, which is flexible, agreeable and functional. Correct lighting plays a big role in paving the way for good visual performance and comfort at work and notably affects the way we respond to the architecture of the building and the interior design.

Until the 1970s, many businesses held fast to the belief that brighter work spaces made more productive workers. The popular design theory was the "blanket of light", which called for uniformly bright stores and offices.(Institution, 2001)When electricity prices soared, many building managers began simply removing out fluorescent tubes, which cut energy costs, but disrupted the lighting design. In some buildings, corridors took on the air of tunnels, and offices grew steadily dimmer or settled for zones of light and shadow. Lighting manufactures were then quick enough to innovate new designs and capitalize on old research, which brought in lamps with altered mixes of inert gases and high frequency lamps. Under the title "Demand-Side Management", electric utilities created a series of guidelines and initiatives to help change patterns of energy use. Manufacturers began to create more and more energy efficient lamps. The use of dimmers, timers, and occupancy sensors further saved energy which some building codes have now made them mandatory. Within the profession, designers, engineers, and trade groups began to recommend generally lower lighting levels. Many designers moved away from the "blanket of light" approach to "task lighting". A more

sophisticated use of natural light in designs also helped to save energy. Studies showed that reducing ambient lighting and using localized lighting for specific visual tasks creates a more comfortable experience for workers. This resulted in layered lighting design based on the task/ambient concept.(Licht, Good Lighting for Offices and Office Buildings 4, 2000)

The image below illustrates the evolution of office spaces from individual offices to multifunctional large spaces. Today's designs are moving toward giving employees a choice of spaces based on organizational goals and a variety of factors that make up a company's "DNA." (Shelow, 2015)

Image below: Workplace Design Evolutions (Shelow, 2015)

2.2 Functions of an Office

The type of work conducted in a space is very specific and requires appropriate lighting application. An office comprises of areas with their specific lighting requirements, these areas include:

-Work area

This area is where employees spend most of their day. Depending on the arrangement of the office, open setup or the cubicle type setup would require slightly different lighting systems. But work places today are predominantly open with low partitions or no partitions where teams work together. Workplace arrangements here can vary considerably; from strict geometrical patterns to circular organic office spaces. Computer systems and VDU are a big part of a workplace, which are placed facing multiple directions. Often, the furniture and the computer systems are re-arranged depending on change in circumstances. In workplaces, there is a need for a permanent artificial lighting with a controlled day lighting system. A variety of modern direct and indirect pendant luminaires are available to facilitate VDU work, which are specially developed for workgroup lighting in open plan offices. Adequate supplementary lighting is required for vertical surfaces where reading tasks are performed, e.g. at cabinets, wall charts or maps, shelving systems.

-Reception/Lobby

This is usually the first space, which is experienced when one walks into a workplace. For the visitors this is the impression of the building. Reception zones lend structure to the room and call for varied lighting to emphasize their unique character and facilitate orientation in the room as a whole. Bright perimeter zones, e.g. walls illuminated by wall-washers, make the room look larger.

Corridors and Circulation Space

All the office spaces are clustered around the circulation path. Once you have entered the office, it takes you from the entrance to the meeting rooms, work area, conference space and so on. This circulation also acts as the egress or leads you to the egress route in a building. Depending on how they are designed, they narrow tunnel like spaces or broad spaces with intersections, niches etc. In office spaces, since most functional spaces and brightly and well lit, the corridors cannot be lit dimly. Most circulation and corridor spaces are usually neglected and do not receive any daylight due to the lack of time spent here. However, if an element of daylight were to be introduced or daylight be mimicked, this would change the experience of this space entirely.

-**Meeting/ Conference space**;

Lighting solutions for conference rooms must be able to accommodate many different requirements simultaneously: Conference rooms are used for meetings, seminars and must ensure that different presentations on different media platforms can be viewed perfectly. Light solutions also need to be distinguished and impressive because lighting provides atmospheric illumination and leaves a lasting impression on business partners/clients.

-Library

Library spaces may include both open and closed storage systems and also moveable shelving systems, and may be applicable to file rooms and other dense storage rooms of material in conditioned office environments. Libraries are assumed to be of general purpose, and could include display spaces and reading, meeting, and electronic workstations. Daylight would be the best kind of lighting in a library. However, in its absence, the lighting for the shelves and the seating areas will have to be considered carefully.

2.3 Office lighting design

Office lighting has evolved along with the changing office spaces and working systems. Traditionally, office lighting addressed workability and the needs of employees; today we are looking to address human biological needs, enhancing spaces and higher efficiency. The way Zumtobel puts it is as follows (Zumtobel, 2013)

Traditional quality criteria	**New quality criteria**
– Glare limitation	– Changing lighting situations
– Good modelling	– Personal control
– Correct light colour	– Energy efficiency
– Avoidance of reflections	– Daylight integration
– Harmonious brightness distribution	– Light as an interior design element
– Sufficient illumination level	
– Appropriate colour rendering	

To ensure the right standard of lighting for a specific room, the right balance needs to be struck between visual performance, visual comfort and visual ambience. The emphasis may need to be on visual performance, which is primarily defined by lighting level and glare limitations, visual comfort, which depends mainly on colour rendering and harmonious brightness distribution, visual ambience, which is essentially influenced by light colour, direction of light and modelling.

The lighting requirement depends on the structure of the room, the atmosphere that needs to be created and the uses of the room. In most cellular offices, louvered recessed luminaires are the preferred option. Louvered luminaires are economically viable solutions for providing

good conditions for VDU work. Lighting standards like the SLL Code of Lighting and the EN 12464-1:2011 use the parameter of cylindrical illuminance for accurate identification of spaces and other vertical surfaces and objects in a room. Cylindrical illuminance is the mean vertical illuminance on the surface of a cylinder. (See image below)

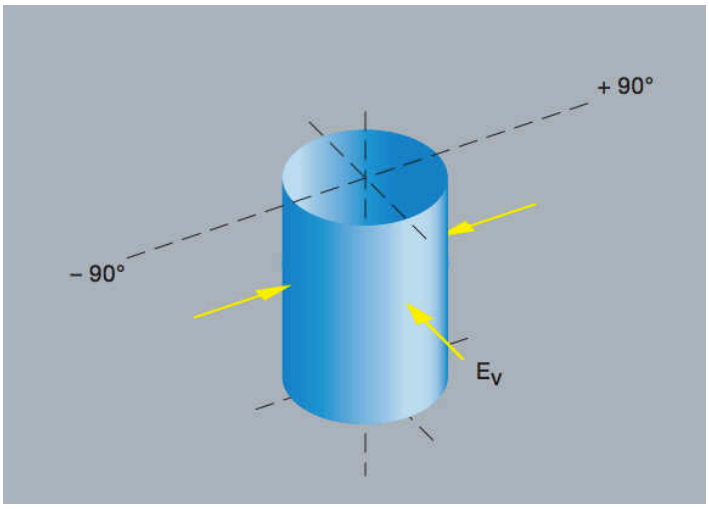


Image: Cylindrical Illuminance (Licht, Cylindrical illuminance)

As per CIE standards, in terms of lamp selection, a parameter called the Unified glare rating or UGR is considered. This is calculated in a precise manner. Simply put, it measures the luminance of a lamp divided by the background of visible luminance from the room. The formula is as follows;

$$\mathrm{UGR} = 8 \log \frac{0.25}{L_b} \sum_n \left(L_n^2 \frac{\omega_n}{p_n^2} \right)$$

where log is the common logarithm (base 10), L(n) is the luminance of each light source numbered η, ω(n) is the solid angle of the light source seen from the observer and ρ is the

Guth position index[3], which depends on the distance from the line of sight of the viewer. The UGR value varies between 5-40. Generally a lower UGR value is better.

The artificial lighting possibilities for office lighting can be broken down into three categories which are as follows

- Direct lighting/ Ceiling recessed

- Direct indirect lighting/ Pendant lights (with downward special optics or general lighting)

- Free standing lighting/ personal desk lighting

- Mimicking daylighting

Direct lighting is highly directional; it could cause strong glares at certain angles. Directional lighting needs to be controlled in an office environment to avoid direct or indirect glare. An office space with only direct lighting would result in dark ceilings and subsequently result in dark corners (cave effect). Unless the entire ceiling is punctured at regular intervals, flexibility of workstation layout is limited. However, at task level, directional lighting is the most energy efficient.

Indirect Lighting creates a diffused lighting condition. Due to the diffusion on the room surfaces, it tends to look bigger. E.g. when diffused indirect up-lights are used, it makes the space seem bigger and the ceiling higher. This is a big element in office lighting since it bypasses all possibilities of glare. Indirect lighting provides for flexibility in workstation organisation and VDU screen directions. However this solution uses more energy.

Direct/ Indirect lighting creates a good room impression. Bright surfaces pleasantly enhance the room atmosphere. This kind of set up is most favourable in offices. It provides a good

[3] Guth position Index- displacement from the line of sight

contrast ratio by indirectly lighting the ceilings and providing sufficient task lighting downward. In order to control the cylindrical illumination and cut down glare, the downward light angle can be controlled by optics or louvers. Direct/ Indirect lighting allows for flexible workstations, provided the indirect component is greater than 60%.(Zumtobel, 2013)

Freestanding Lighting/ Personal lighting- Freestanding lamps are those which can be controlled by a user at desk level. Local control of task lighting promotes worker satisfaction. Recessed luminaires provide ambient lighting. Articulated desktop luminaires provide higher light levels when necessary and help in providing higher levels of light for a only a short while in short term tasks.

Recessed luminaires and direct/indirect lighting provide ambient lighting while articulated desktop luminaires provide higher light levels when necessary. Ambient lighting system has an orderly appearance but spacing may vary. Luminaires may be spaced more closely over work areas for efficient downward lighting. The luminaires will need to distribute light to the vertical surfaces in addition to horizontal task surfaces for good cylindrical illuminance. Recessed luminaires are most appropriate for open plan spaces with ceilings 8'4" or lower, since they do not illuminate the ceilings and have a greater potential for high angle glare and UGR. Suspended luminaires provide better quality for open plan ceiling heights above 8'-4".(NBI, 2011)

Mimicking Daylight can be called the forth component of artificial lighting. This kind of lighting depending of kind of implementation can provide for the quality factor in an office space. Besides efficient lighting and meeting correct light levels with glare free luminaires, mimicking daylighting can add to the wellness of the employees. This concept would essentially work well in deeper spaces in plan, which lack sufficient daylight.

Across the globe, different regions/ countries have their own standards and lighting recommendations. The illuminance values recommended apply to the task area in which the visual task is performed. The task area can vary. It could be a horizontal (e.g. table), a vertical (e.g. map) or an inclined surface (e.g. drawing table). Task areas typically found in an office are desks, conference tables, the vertical surfaces of cabinets and shelves, and stations for office machinery such as fax machines and copiers. Outside of these task areas, a lower lighting level is permitted since the surrounding space is not used for the performance of any demanding visual tasks. The following table shows the illuminance values required for task and surrounding areas and the minimum uniformity of illuminance expressed as the quotient of minimum and mean values:

Task area	Surrounding area
≥ 750 lx	500 lx
500 lx	300 lx
300 lx	200 lx
up to 200 lx	up to 200 lx
$E_{min}/\bar{E}_m$	$E_{min}/\bar{E}_m$
min. 0.7	min. 0.5

Table: Task area lighting to surrounding light levels. (Licht, Good Lighting for Offices and Office Buildings 4, 2000)

The biggest challenge in tackling office lighting is Glare. Glare is one of the most discomforting factors of all visual problems. An unshielded general-diffuse lamp or the bright reflection of a window on a VDU screen places substantial strain on our eyes. Glare can have physiological consequences as well (e.g. impairment of visual acuity). A bright reflection on

a screen may also obscure information and render it indecipherable. In most cases, glare has at the very least a psychological impact, causing fatigue and loss of concentration.

There is a distinction to be made between direct glare and reflected glare. Direct glare occurs where a very bright point of light (e.g. the lamp of a luminaire) is located in the visual field. Direct glare can be avoided by using appropriate luminaires and correct positioning of luminaires at workplaces. Reflected glare often occurs as a result of reflections on shiny or reflective surfaces. These surfaces can be VDU* screens, items of furniture or glossy paper. To avoid reflected glare, it is necessary to look at not just the type and arrangement of luminaires in the room but also the materials and finishes of the office furniture and the positioning of monitors and other reflective office objects.

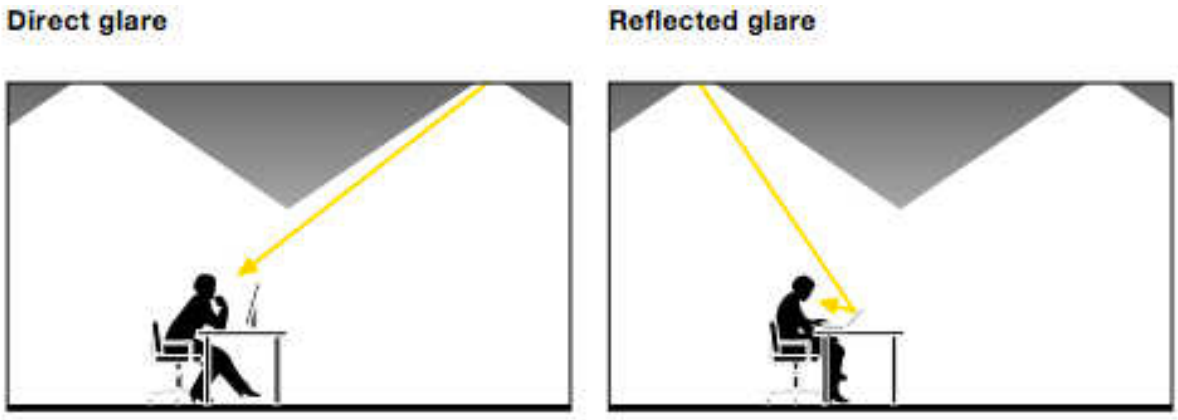


Image Above: Glare illustration (Zumtobel, 2013)

In task lighting, the task size and the relative lighting in its surrounding is more important than just the level of light. Obtaining the correct contrast of task area and surrounding area is more important than independent task area light levels. (Veitch, J.A, Galasiu, & A.D, 2012)

Lighting Controls

Even though light switches are usually within easy reach in cellular offices, lighting control systems have distinct advantages. Lighting control can provide for the right light at the right place and at the right time. It can enhance visual comfort and optimize visual performance by regulating light through the different scenes and time of the day.

In the case of daylighting, it can activate light rightly to the correct light levels for the required function. With the use of lighting control and management, the right balance of daylight and artificial light can be achieved. Apart from this, lighting control system can perform dynamic setups such as the kind required for human centric lighting or simply any dynamic lighting programme to take away from the monotony of an office space.

Using lighting controls, the mood of the room can be defined. It helps cast rooms in the right light. (Licht, Good Lighting for Offices and Office Buildings 4, 2000) Pre-programmed scenes can change the nature of the room e.g A well lit meeting room can change into a conference room or a dimmed down presentation rooms by turning off/ on lights or dimming them. This makes lighting control and management an essential part of good interior design and lighting design.

One of the most important advantages of lighting control systems is cost saving. Economical impacts are always a major consideration in the running of the building. Several types of occupancy sensors, timers, light level monitors and so on can be integrated with control systems to achieve efficient lighting. When lights are turned off when not needed, it drastically cuts down the energy consumed. Especially in corridors, stairwells and circulation areas which are used minimally, lighting can be dimmed down to a minimal level which would save power. According to studies done in the field, it has been proven that the

occupancy sensors are more efficient in comparison to manually tuning off lights when not in use. (Jennings, Blanc, Francis, & DiBartolomro, 2013) Modulating the lighting according to the lows and highs of daylight is also an energy saving technique in the lighting management system.

The following factors have a positive impact on the reduction of energy consumption (Zumtobel, 2013)–

–Sensible control of lighting

– Use of daylight

– Use of presence detectors

– Intelligent consideration of hours of use

– Energy-efficient lamps

– Need-based use of luminaires and lighting solutions, specified for the respective application

– Constant lighting control (maintenance control)

2.4 Preference of day lighting in office spaces

Health Benefits: As mentioned earlier in the paper, on the benefits of daylight on Human lives, it also has psychological benefits. Since daylight contains all the spectrums of light, human functioning unlike with artificial lighting, is known to be enhanced. (Vandewalle, et al., 2006) The secretion of Melatonin, which is the regulating hormone of the human body, relates to sunlight. Melatonin dictates human activities, consciousness and level of alertness. The rhythm of sunlight keeps the human circadian rhythm in check.

Natural light increases attention and alertness during the post-lunch dip and research shows that its helpful in increasing alertness for boring or monotonous work (Boyce, 1997)

There is an innate need for the human mind to be connected with the outdoor and not feel cut off from the outside world. This is an important psychological consideration when mimicking daylight with artificial lighting. (Edward & Torcellini, 2002)

Architectural Advantages: A space with a window or fenestration is perceived bigger than one without. An opening in the indoor connects the indoor and the outdoor space, which can have a positive impact on the employees. Its believed that a simple yet important impact from daylighting could be a more positive mood for employees. Increased job satisfaction, work involvement, motivation, organizational attachment, and lowered absenteeism could result from an improved mood.(Edward & Torcellini, 2002)

Collins in his research found that 35% of participants were quick to respond that the absence of windows was their greatest trouble with their office space. The reasons given for the dislike of the windowless offices were: **“no daylight, poor ventilation, inability to know about the weather, inability to see out and have a view, feelings of being cooped-up, feelings of isolation and claustrophobia, and feelings of depression and tension.”**(Collins

1975)

The study, "Occupant Satisfaction with Indoor Environmental Quality in Green Buildings," showed that quality lighting is critical to building occupants. The study uncovered that one of the main reasons individuals are disappointed with their IEQ[4] include poor lighting quality. (Lind, 2010)

Approximately equal numbers of people who were surveyed from both green and non-green buildings were upset because:

1. There was not enough daylight

2. There were reflections on computer screens

3. The buildings were too dark

4. The buildings were too bright

5. There was no task lighting available for employees

[4] IEQ- Indoor environmental Quality

2.5 Risks of a windowless space

Studies show that daylight in factories affect the physiological and psychological health of employees. Sweden built the first underground, windowless factory in 1946 and it was later discovered that the workers in the factory developed many health problems. The workers complained of headaches and fatigue, and strongly voiced their discomfort. (Edward & Torcellini, 2002). In 2014, an interdisciplinary team of architects and medical researchers conducted a case study comparing people exposed to natural light at their jobs with those who are not. The workers with access to windows at their workplaces scored better on common self-report health and sleep surveys. They also slept 46 minutes more at night, on average, as measured by a sleep monitor (Jaffe, 2014)

Physiological Effects

Research from Russia and Czechoslovakia has shown that workers in windowless factories have more headaches, dizziness, and illness compared to workers in factories with windows (Plant 1970). Volkova (Hathaway, et al.1992) tested the blood of workers in an underground, windowless factory and found that windowless factory workers experienced an increase in permeability of skin capillaries, decreased white cell activity, and increased catarrhal infections and colds.

Studies by Trysin in Swedish underground factories found that lighting levels, inadequate ventilation and inappropriate colour schemes also affected the employees negatively and further advised that workers should take longer rest periods in daylit rooms or outside (Collins 1975).

Psychological Health

In his 1964 study on windowless environments, Pritchard reviewed personnel managers'

reports on workers claims about their health and found that the workers complained of claustrophobia and unhappiness from the windowless environment. In another study N. Ruck has noted that workers in windowless factories complained of increased headaches and general depression. Also indicated in the research findings were increased absenteeism problems and a hike in vandalism in the windowless factories (Abdou 1997).

In other findings F.D. Hollister found that underground working conditions forced factory workers to craft their own solution for their need to have contact with the outside world. Hollister noted that the employees achieved that by breaking so many wall panels that it became necessary to provide some visual contact with the outside world. (Edward & Torcellini, 2002)

Productivity and Safety

By enhancing the light in industrial environments, the time taken to perform a specific task may decrease. Some of the earliest studies concerning the impact on productivity of workers and lighting in buildings were done within an industrial environment, by looking at the relationship between lighting and silk weaving, linen weaving, and typesetting by hand (NEMA 1989). In a study done by Bennett, Chitlangia, and Pangrekar (Abdou 1997), it has been found that people took less time to carry out various tasks of probing needles, map reading, and measuring the diameter of bolts, among other things, when luminance was increased. Changes in performance are due to improved colour rendering as well as better safety for workers from better light. These studies give evidence for a clear relationship between work output and the quality of light available.

Boyce and Simmons studied the effect of light on colour judgment by asking subjects to arrange a series of coloured discs, differing in hue, in a consistent order. The study results showed that full-spectrum fluorescent lights produced the lowest error score in comparison to the high-pressure sodium discharge lamps, which produced the highest error score (Abdou 1997). It was found, in three European industrial studies, that accident rates dropped by approximately 50% when lighting was increased from 15 to 100 foot candles (Sucov 1973).

The Prince Street Technologies factory in Georgia uses daylight as supplemental lighting. The carpet-manufacturing factory includes skylights and a picture window that provides a view of natural landscaping on the outside. Before the company moved to the new facility, an average of twenty workers' compensation cases were reported yearly. In three years at the new facility, only two cases had been reported (McQuillen 1998). Frank P. Boardman, manager of creative services for Prince Street Technologies thinks the decreased number of worker's compensation cases was due to the presence of daylight. Other benefits from the natural light have been comfortable working conditions of the mill workers and product quality assurance. (Bertman 2001)

3.0 METHODOLOGY

3.1 Existing Techniques, Case Study

Coelux
Recreates the look of sunlight through a skylight.

Reproduces a virtual experience of the sun and sky by a special LED projector and the concept of Rayleigh scattering.

(Coelux)

Philips luminous textile with Kvadrat Soft Cells
Breitner Tower, the home of Philips in Amsterdam, has dynamic cladding in the restaurant that changes in colour, content and pace to provide a relaxing and inspiring atmosphere for staff. (Phillips)

It features a white gloss cladded corridor, where strips of light are reflected to give the illusion of a never-ending grid.

LED ceiling at Light Fusion Lab at Germany's Fraunhofer IAO Institute

A luminous LED ceiling panel prototypes, which simulate the lighting conditions produced by passing clouds, giving workers the impression that they are sitting outdoors. The researchers - used a combination of red, blue, green and white LEDs to replicate the full visible light spectrum. This combination made it possible to generate more than 16 million hues and allowed them to simulate natural light changes that are not obvious to the naked eye. (Fraunhofer)

Daylight Entrance, Stokholm- Daniel Rybakken

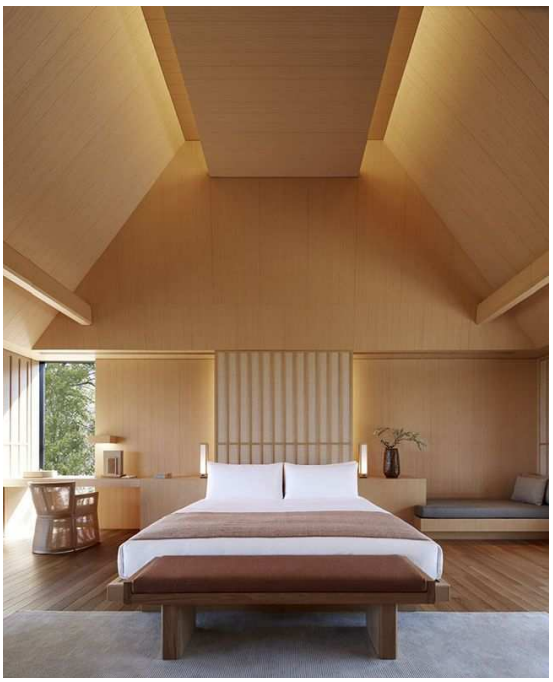
"*The installation is located in the entrance of an office building in central Stockholm. As both entrances and staircase have no natural light, it was important for me to replicate the positive sensation of sunlight. The technical principles behind the project are based on my previous lamp, Surface Daylight*" (Rybakken)

Walls are covered with a solid surface material; CNC- milling hollows areas before backlighting by LED. The installations consist of over 6000 LEDs and continue across three stories.

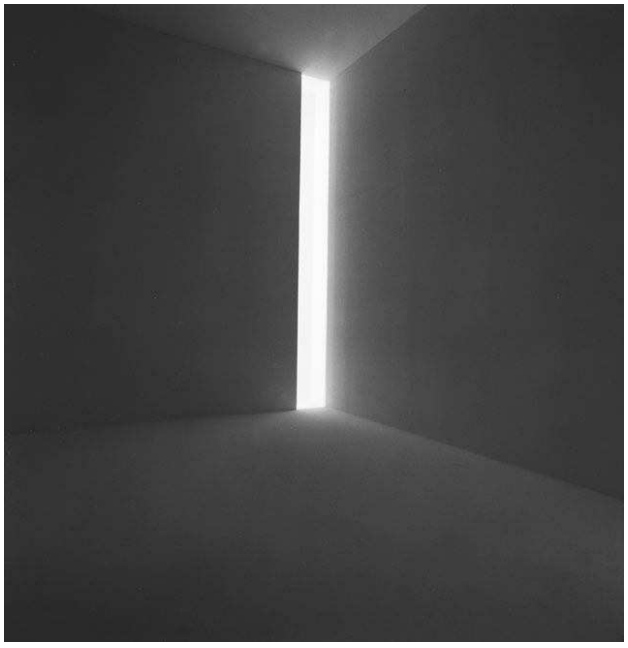
Daylight Comes Sideways-
Daniel Rybakken
"The aim of Daylight Comes sideways was to create a feeling of expanded perceived-space through the illusion of Natural daylight. The idea is to simulate daylight through a blurred, semi-transparent 'window' and indicate outdoor objects using dynamic artificial shadows."
1100 LEDs are dimmed individually in this case, behind a semi- transparent. By dynamically programming it, he is creating a subconscious illusion of a window.

The above cases are carefully crafted to imitate a window or skylight. It is important to take note that most of the above are either installations or extremely expensive attempts to replicate a visible window or skylight. While the cases above replicate daylight in sophisticated manners, the images below also replicate the lighting effect of daylight without attempting to mimic the opening itself. The argument here is that both these kinds of imitations subconsciously make the human mind believe the existence of sky above and provide a connection with the outdoors which is a psychological need when it comes to lighting. This topic has been discussed earlier in Chapter 2.4.

Floating Ceiling (Unknown)



Indirect Lighting (Hill)

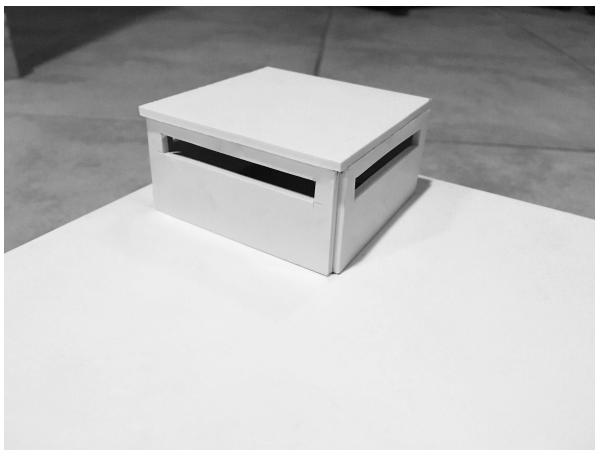


Jim Turrell, Stedelijk Museum (Turrel)

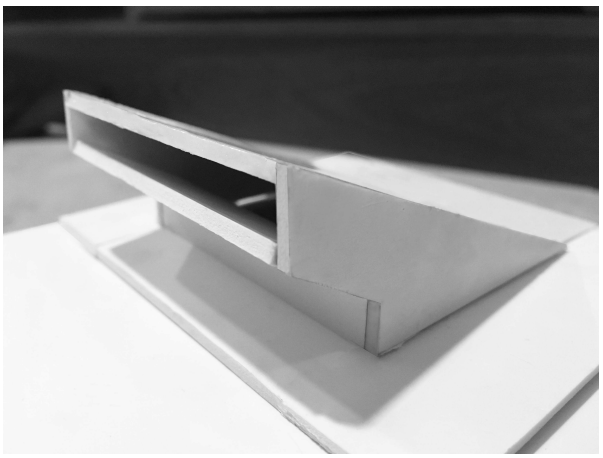
Stepped lighting Ceiling (Ferrater)

3.2 Experiments with model

In order to study the comparison between artificial light and natural light through an indirect skylight, a box experiment was made to a 1:100 scale of a room with a 3 m height, and a 5m by 8 m floor area. Considering the availability of 1 m space above the false ceiling, two modules were prepared which imitated the shape of two kinds of architectural skylights as shown in the fig. below.



Box type Skylight with all four sides opening of 250mm opening



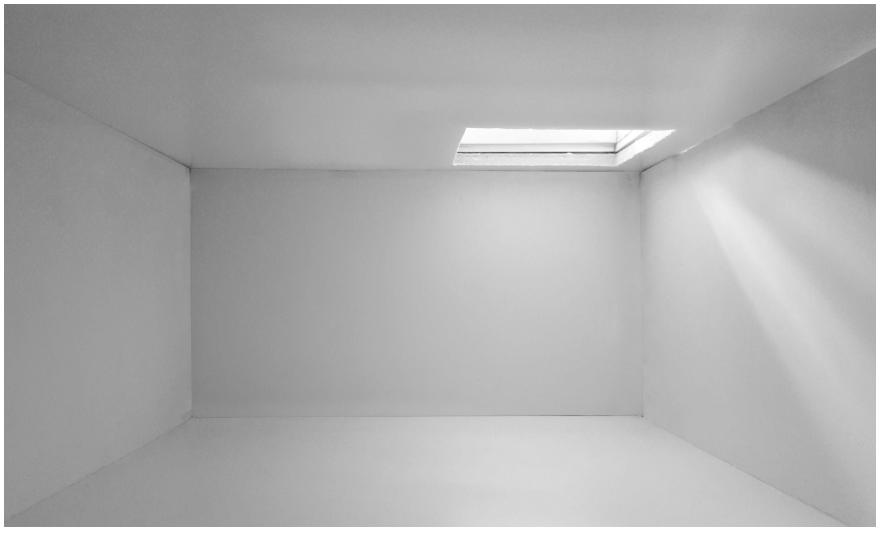
Angles skylight module with an opening of 400mm.

In most high-rise buildings, the floor-to-floor height is max 4m and the false ceiling stands at about 3m clear from floor. Considering the availability of roughly a meter of space above the false ceiling, these modules are designed to fit in. Generally the mechanical equipment's, Air-conditioning ducts etc. run above the false ceiling. By planning at concept stage, the MEP can be designed around the lighting system/ mimicking daylight modules.

The box space was subject to sunlight as well as diffused LED strip lighting with the two different modules to understand the light output and the shadows cast. The resultant images are shown below.

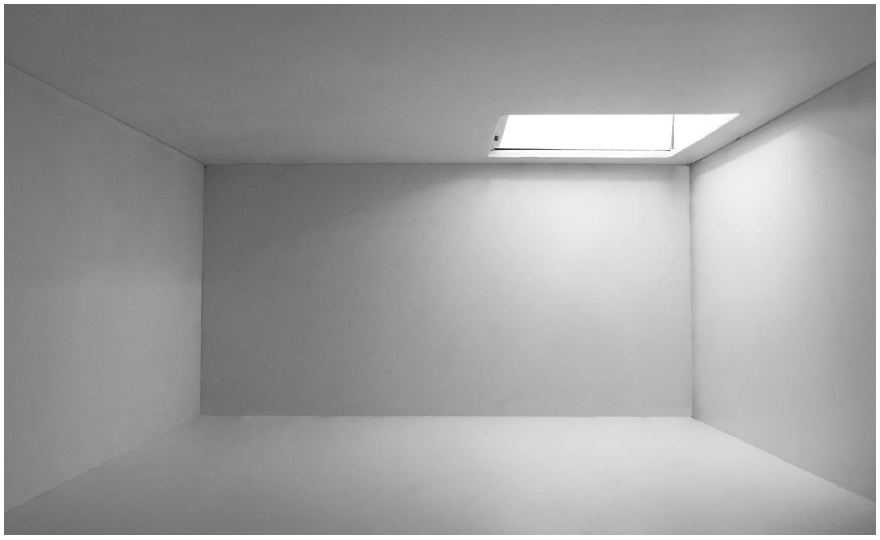
Angled Module with Artificial Light.

Due to the angle of the skylight, it casts the beam of the wall. Using a diffuser on the product would diffuse this light.



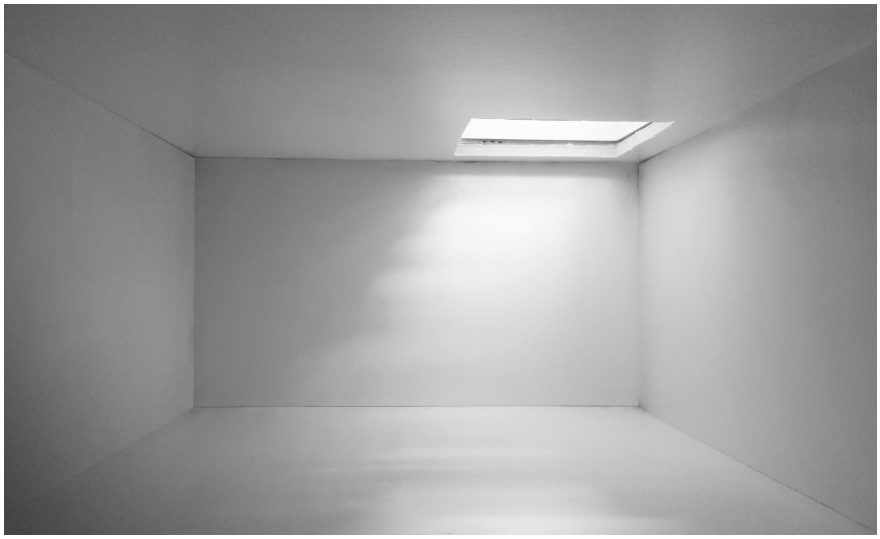
Angled Module Under sunlight.
Time: 1:30 PM
Dubai

This light output is not far different from the artificial light above however light levels achieved in the space are different.



Box Module with artificial Light.

Since the skylight cut-out are on all 4 sides, it allows more light in that the skylight above and creates a 360˚ glow which would work ideally in an office environment.



Box Module under Sunlight.
Time: 1:30 PM
Dubai

Similar to the image above, there is a 360˚ diffused glow along with some strong light on the wall in front. This stronger direct beam would be dynamic with movement of the sun.

Fig Above: LED Film Used to produce diffused lighting. Product used : Cool Edge strip, 4000K Color Temp on a 1-10V dimmer.

3.3 Survey Questions

This survey consisted of multiple-choice questions with images, which were distributed among office workers. They were asked to input their age and kind of office they worked at. The following are the survey questions

1) What is your age?

-20-35

-35-50

50-65

65 and above

2) What is your work space like?

-Corporate Office

-Personal Office

-Entertainment studio

-Design studio

-I don’t have a fixed office

3) Do you think the lighting in your work place can influence your mood and alertness?

- Yes

- No

4) Do you think Daylight is necessary in your workspace?

Yes

No

5) During morning hours of work (8:00AM- 12:00PM), would you like to work in Warm neutral or cool lighting? (Please see reference images below)

-Warm Lighting (2700K)

-Neutral Lighting (4600K)

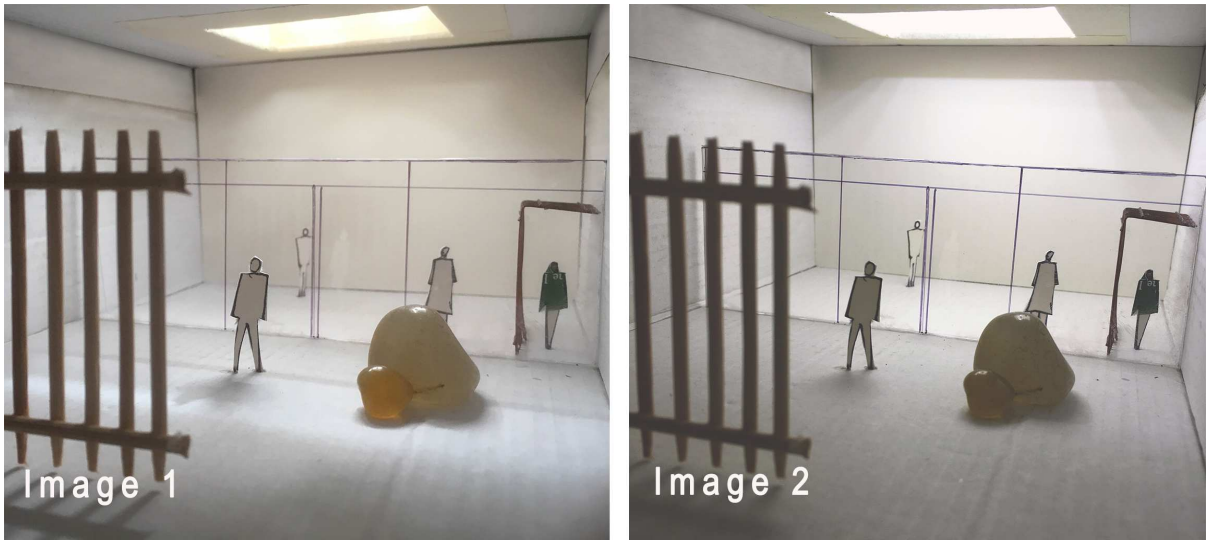
-Cool Lighting (6500K)

6) Which of the following box models images do you think is daylight/natural light?

- Image 1

- Image 2

- Both Images



7) In terms of keeping you alert post lunch, would you prefer to work under warm, neutral or cool light?

-Warm Light

-Neutral Light

-Cool Light

8) Do you think it would be beneficial to have adjustable white light (between warm neutral and cool light) in your office workspace throughout your day?

-Yes, I'd like to control my own desk lighting

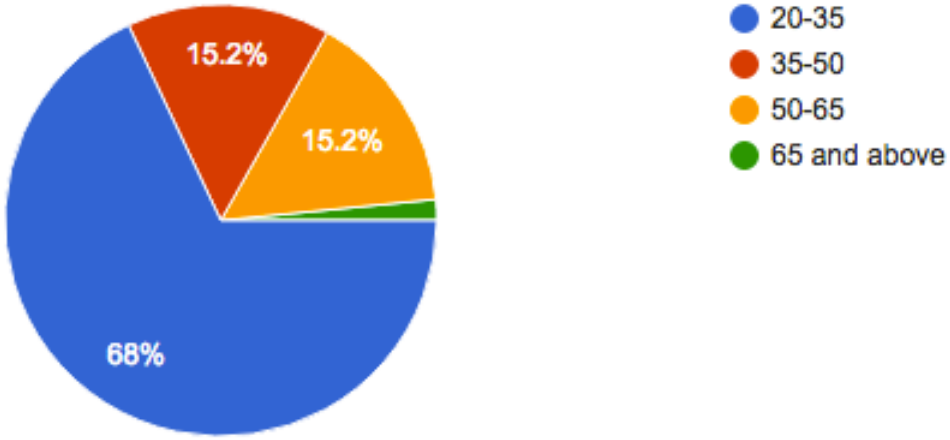
-Yes, if it is centrally automated

-No

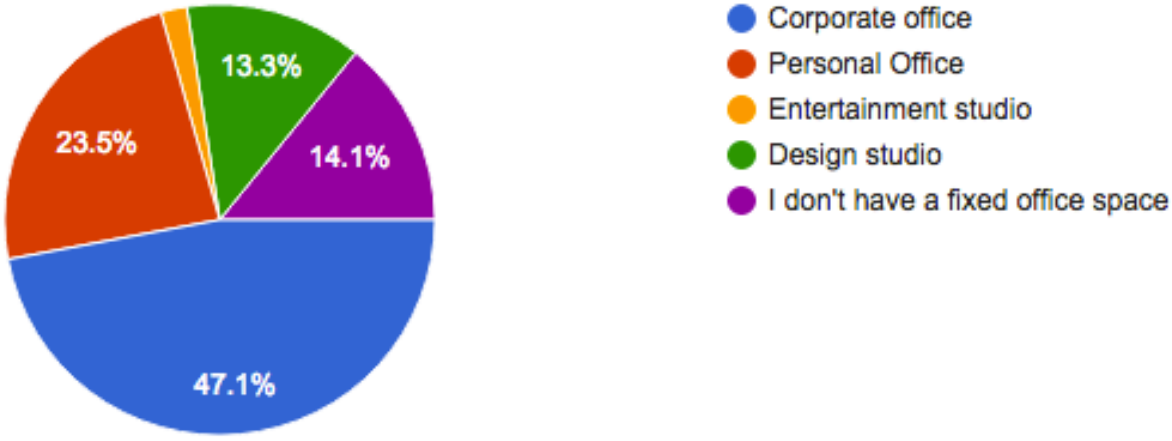
3.4 Data Analysis

Below are responses to the above survey displayed using graphs.

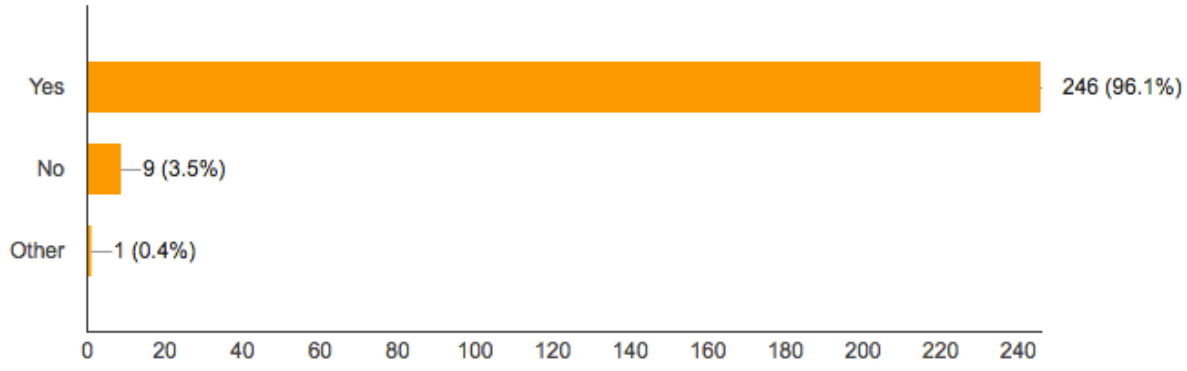
1) What is your age?



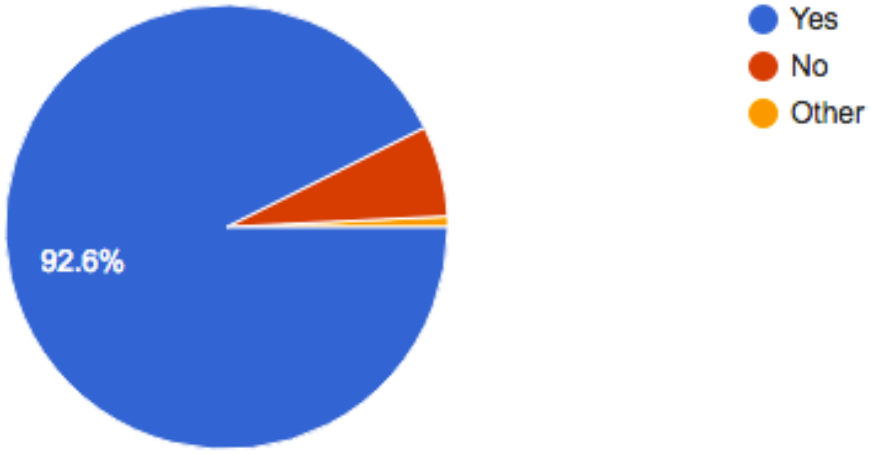
2) What is your wok space like?



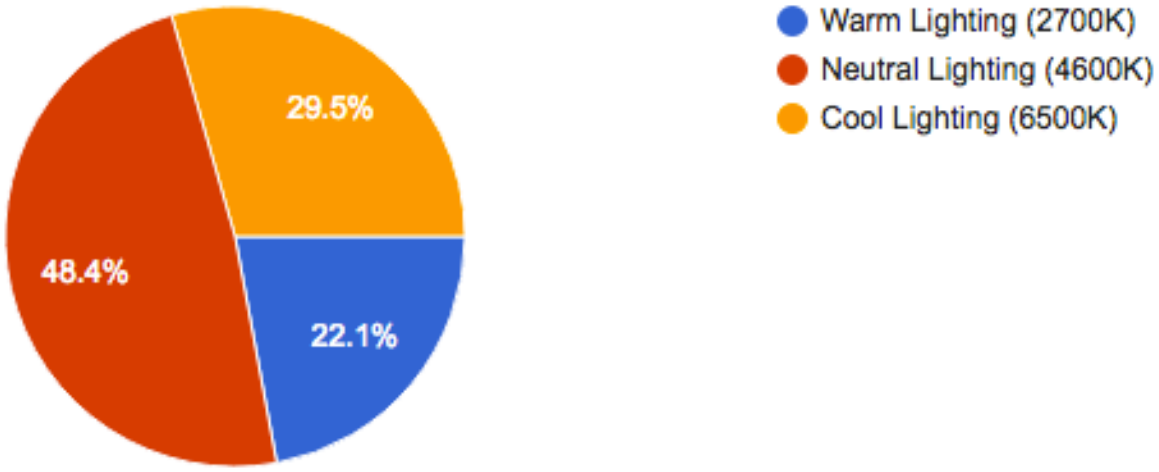
3) Do you think the lighting in your work place can influence your mood and alertness?



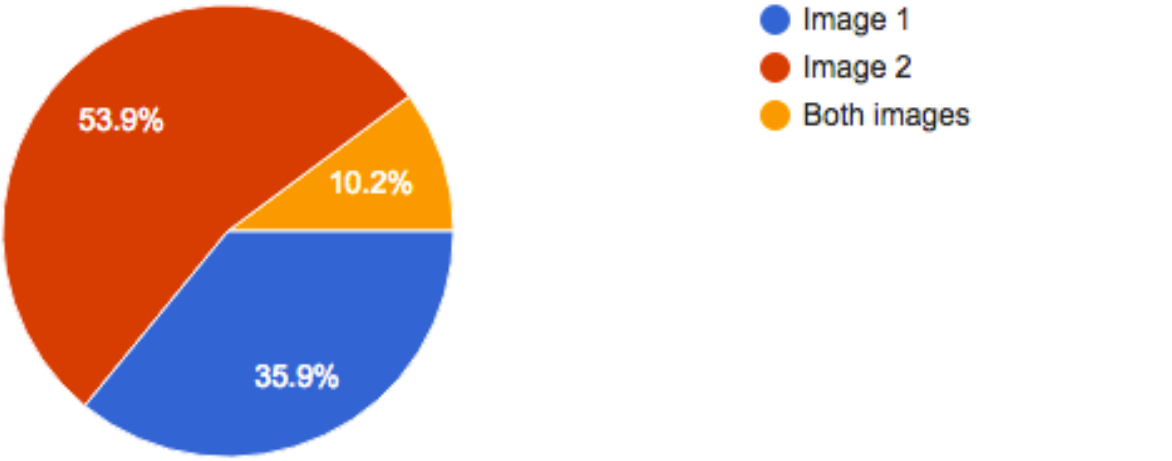
4) Do you think Daylight is necessary in your workspace?

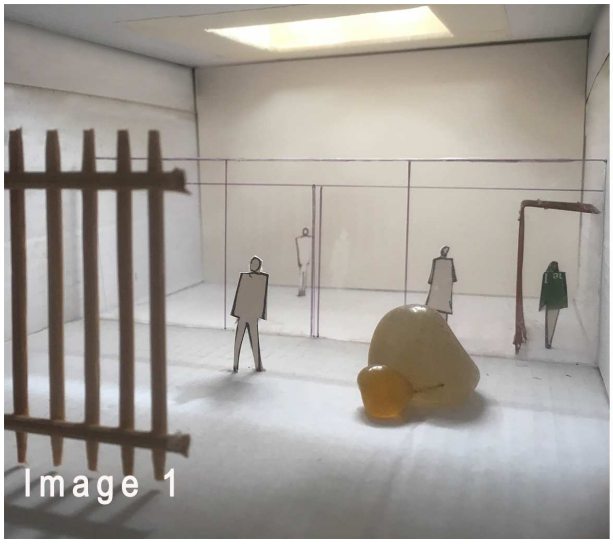


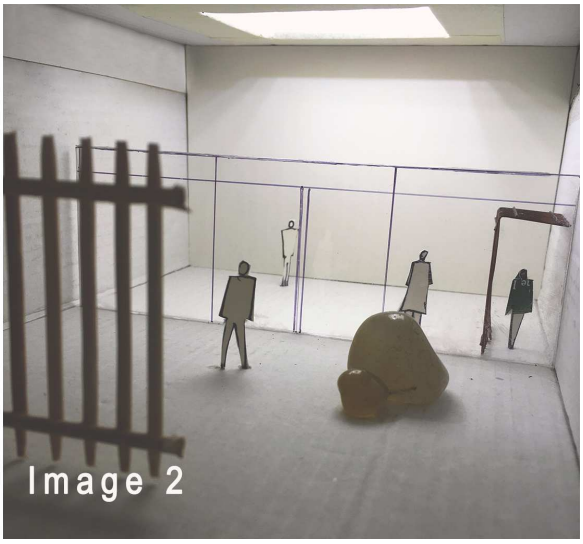
5) During morning hours of work (8:00AM- 12:00PM), would you like to work in Warm neutral or cool lighting? (Please see reference images below)



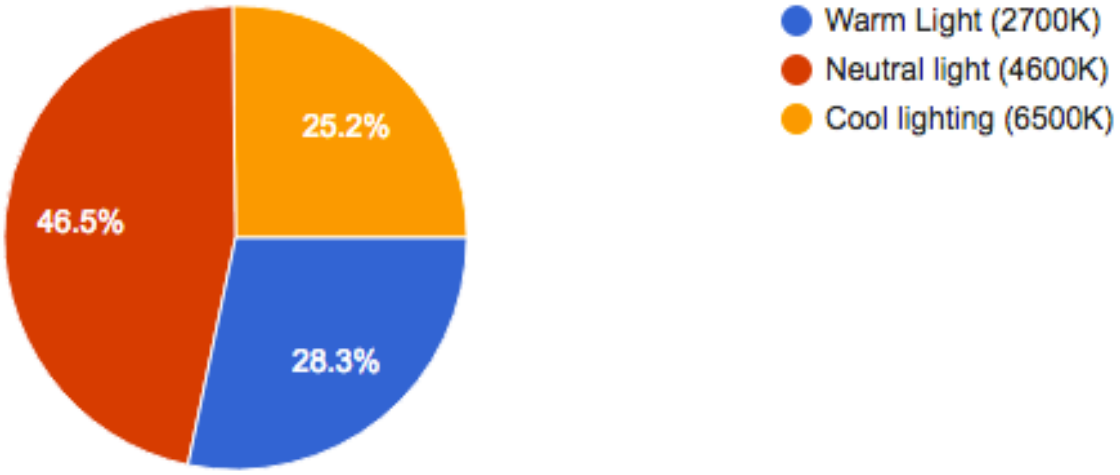
6) Which of the following box models images do you think is daylight/natural light?



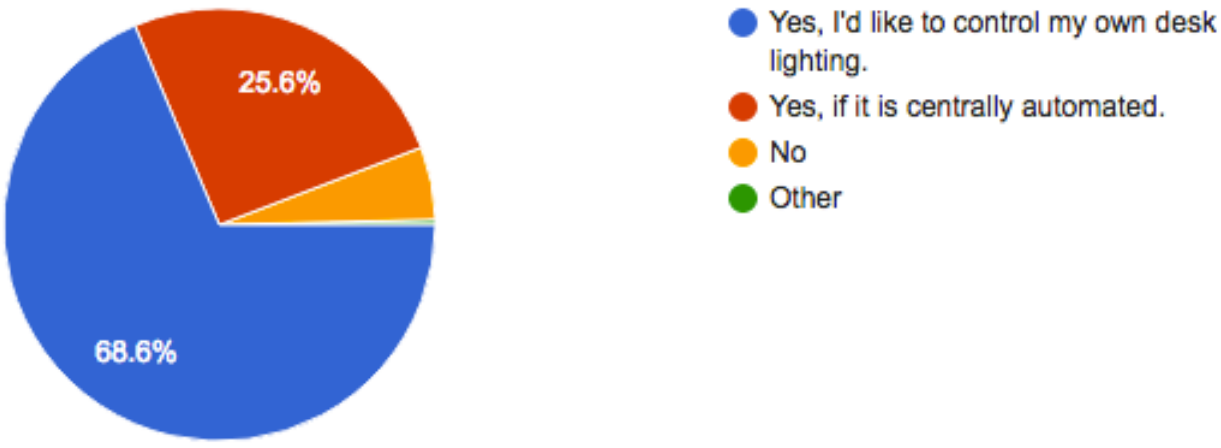




7) In terms of keeping you alert post lunch, would you prefer to work under warm, neutral or cool light?



8) Do you think it would be beneficial to have adjustable white light (between warm neutral and cool light) in your office workspace through your day?



A total of 260 office goers answered the survey questionnaire. The majority (68%) of them were between the ages of 20-35 years. All respondents work in different office spaces ranging from personal, corporate to design studio setups.

Most respondents agreed that lighting has an impact on their moods. When asked if good lighting can improve mood and in-turn increase productivity, 96% of them agreed. Most of the respondents (92.6%) also agreed that daylight is necessary in office lighting.

When it came to preferences of white light CCT for the different times in the day, 48.4% of responses favoured neutral light in the morning and 46.5% of responses prefer neutral light post lunchtime. 28% of respondents chose to work under warm light in the morning and 22% chose to work under warm light in the noon too. Almost 30% of the respondents preferred to work in cool light in the morning and 25% chose cool, even light post lunch.

However it is interesting to note that about a 94% of people would be interested in a dynamic white light CCT throughout their workday. This may also mean that there would be a positive response to HCL lighting.

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4.0 THESIS QUESTION

4.1 Ways to mimic Daylighting in an Office Space.

From the above literature review and study the following possibilities are gathered as a response to the thesis question.

1. Mimicking CCT properties of sunlight/ Human Centric lighting
2. Mimicking outdoor Dynamism
3. Mimicking the physical architecture of skylight
4. Using lamps with visible light composition closest to Natural light

1) **Mimicking sunlight by the changing CCT/Human Centric lighting**

HCL, also known as Human centric lighting is a relatively new concept in lighting. HCL means lighting that is designed around the needs of a human being. Correct lighting design has always followed function, but now with HCL we are talking about lighting following Human Biology. In order to address human biology, it is crucial to understand the human reaction and response to light. Ever since the discovery of the non-visual photoreceptors, the ipRGC[5] in the human eye and its direct relation with the light exposure, research has lead us to believe that light can modify the human circadian as discussed earlier in section 1.1.
This concept is most relevant today because of our increasing practices of indoor large open office spaces with only peripheral windows and increasing work hours in offices. There is a desperate need in all fields to ease work stress and improve quality of life. While lighting companies have always found it easy to market in the name of health, HCL lighting hasn't been able to penetrate the markets as expected due to scepticism from the public due to lack of knowledge and research data on the subject. A market study conducted by Lighting Europe proves a high potential for the concept of HCL in the education sector, white-collar workstations as well as hospitals. (Cajochen, et al., 2009)

The third photoreceptor in the human eye is most sensitive to the shorter wavelengths of visible light and it has the ability to moderate the circadian cycle in the human body. The human body goes through sine waves of melatonin, cortisol, sleep and alertness throughout the 24- hour cycle. This cycle as we know relates to the circadian rhythm. (Vandewalle, et al., 2006). As you see in the fig. below, for a regular daytime worker, the melatonin and cortisol release in our blood does an overlapping curve at about 6:00am in the morning as we wake up and the melatonin gradually drops and the cortisol picks up. As per behavioural

[5] ipRGC- Intrinsically photosensitive retinal ganglion cells.

observations (Bieckmann, 2016) of subjects exposed to white light in the mornings, there has been suppression in the melatonin and a boost in the alertness levels. Since the melanopsin in the eye is the most sensitive at the shorter wavelengths, it is the blue spectrum of white light, which is responsible for this shift. Similarly they have noticed that the blue light exposure in the evening during the rise of the melatonin, leads the curve to shift away in time. (Bieckmann, 2016). Repeated shift and altering would lead to irregularities and result in imbalance.

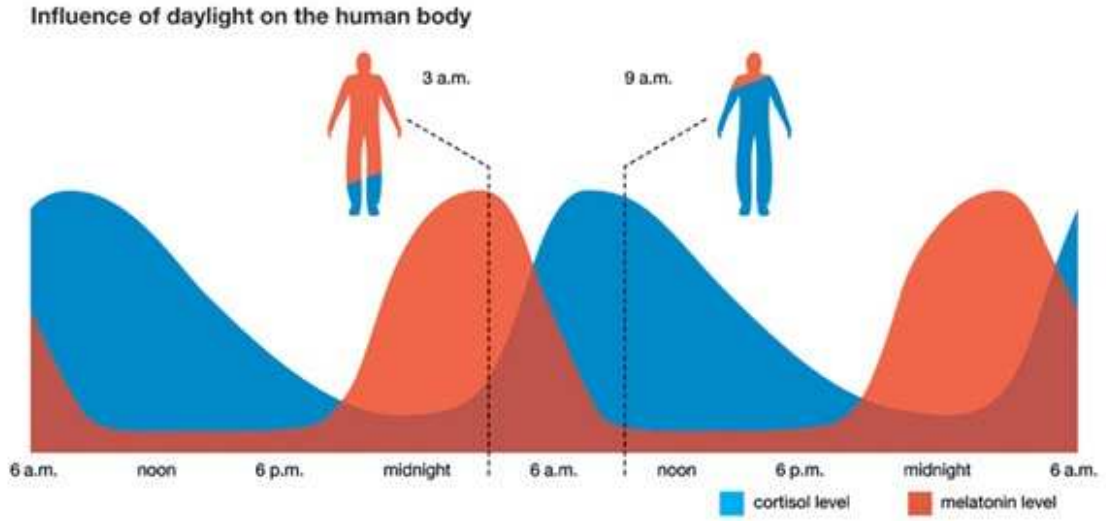

Fig. 3. Graph indicating cortisol and melatonin levels against time.(Licht.de, 2013)

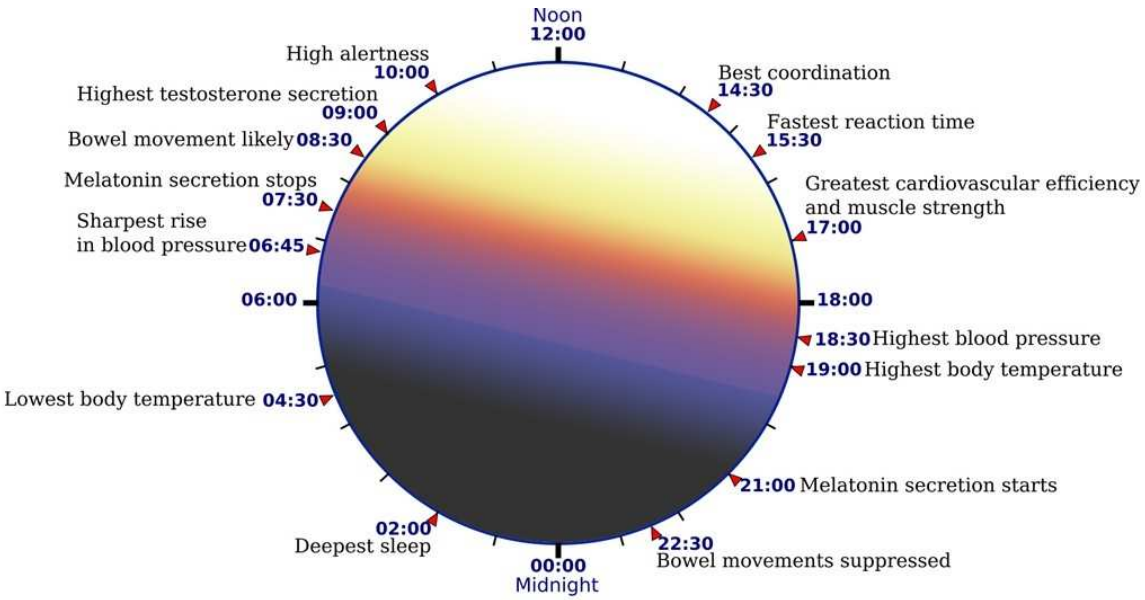

Fig. 4. 24-Hour body cycle (Martin)

Human centric lighting is a compensation for the lack of daylighting. As we have accomplished that as of today, only diffused sunlight can be imitated which is known to be the best kind of light in an office set up. In order to achieve light similar to that of diffused daylight from an electrical light source - this would mean varying the colour temperature as well as the intensity of the white light. Ideally to match spectral composition of daylight to the max, the lighting module would need a full spectrum of visible light, alternatively, a multi-chip LED, which can be dimmed accordingly. Due to the lack of awareness about light sensitivity, most often tuneable white lamps are used for human centric lighting where the module contains two separate chips of two different CTT which are controlled separately to create the desired mix of colour temperature and dimmed simultaneously and/or independently to produce the desired intensity.

HCL is not only able to be implement with the aid of LEDs, but also with fluorescent lamps, which were used several years ago. However, LEDs today are more advantageous because of the flexibility they offer in size, compactness, and energy efficiency. RGBA and RGBW chipsets can be used to great effect.

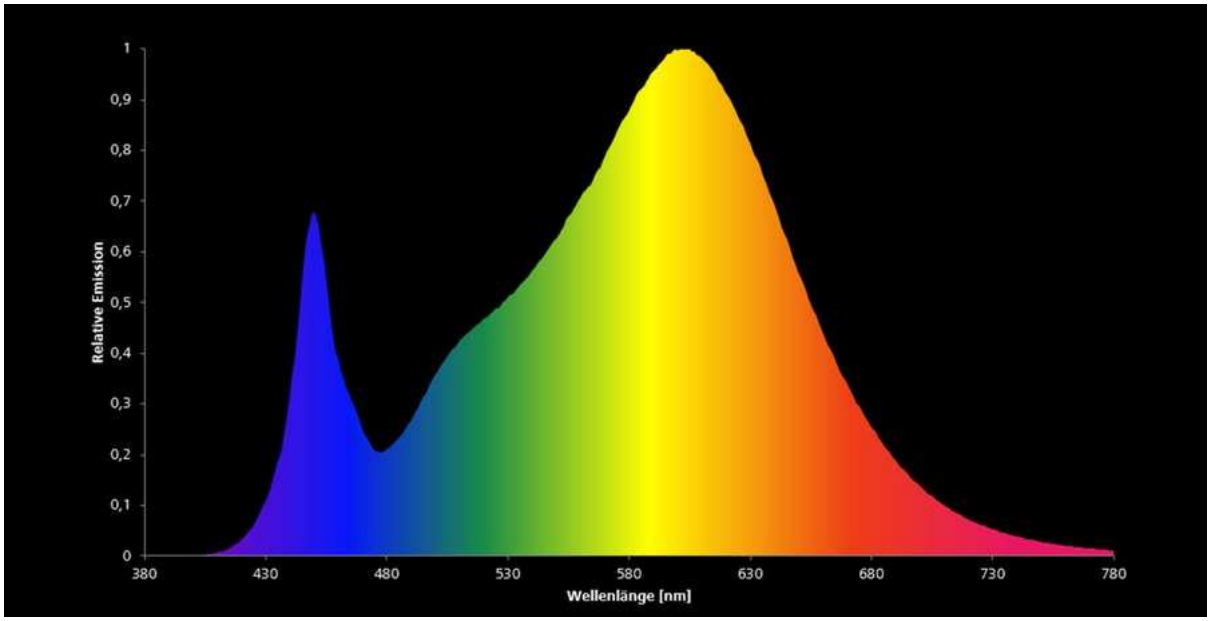

Fig. 5. Spectral distribution of an LED with color Temp. of 3000K (DIAL, Illustr. 02: Spectral distribution of an LED with a colour temperature of 3000 K, graphics)

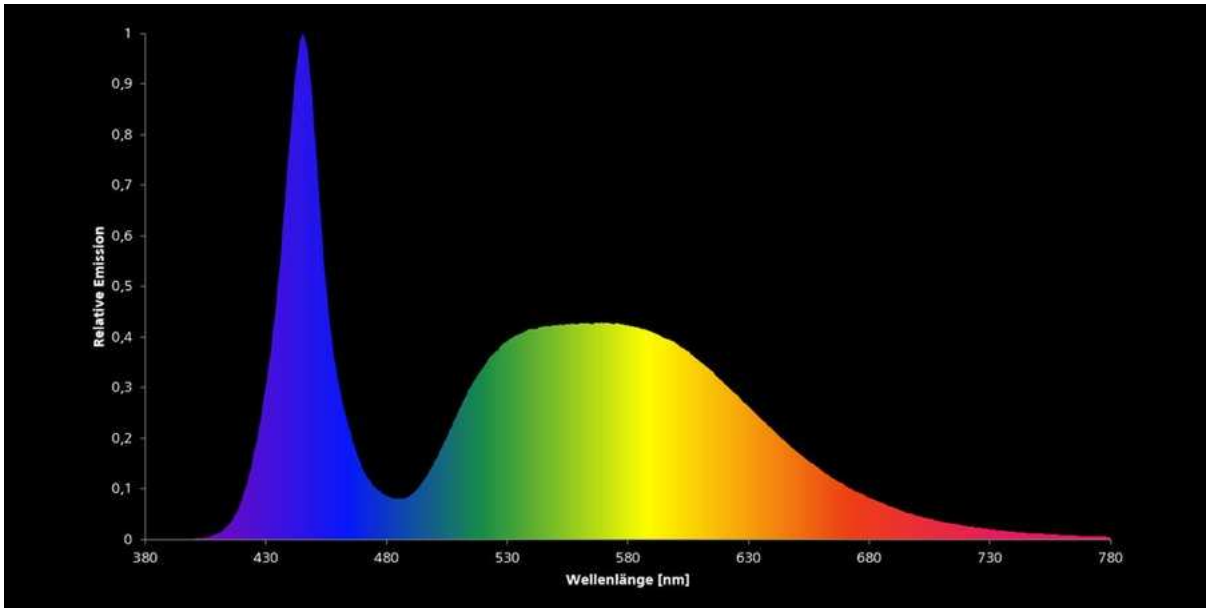

Fig. 6. Spectral distribution of an LED with color Temp. of 5000K (DIAL, Illustr. 03: Spectral distribution of an LED with a colour temperature of 5 000 K, graphics)

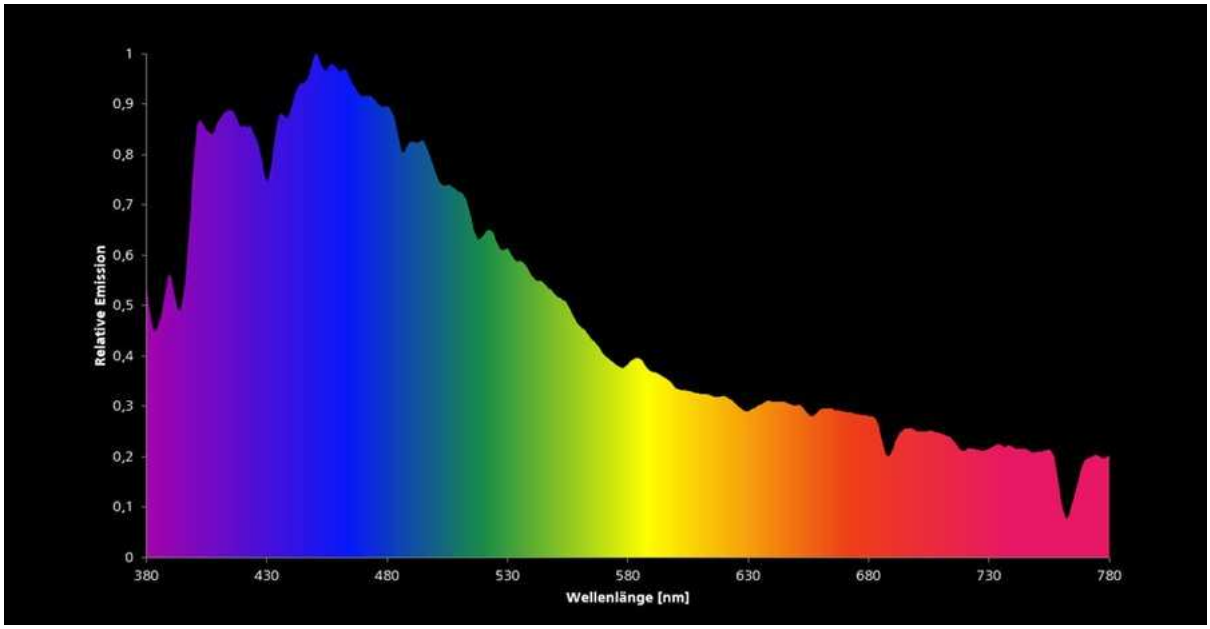

Fig. 7. Spectral distribution of morning daylight at 18 000K (DIAL, Illustr. 04: Spectral distribution of a blue sky in the morning with a colour temperature of 18 000 K, graphics)

For activation of HCL, ambient lighting over a large area in the upper half of the room (e.g. through mimicking the architecture of skylights as mentioned below) plays a big role since this has a greater biological effect than in the lower half of the room. This light reaches the lower half of the retina in which most ipRGCs are found. This is practically identical to the diffused, cool white light from the sky (correlated colour temperature approximately 10000k to 25000K). Research recommends that after nightfall general cool white lighting in the upper half of the room should be avoided unless conscious activation is intended, in which case warm white lighting ought to be utilized. However, the direction of the light should also be considered.(Bieckmann, 2016)

In principle, HCL can be implemented in two ways; First situation is when the Indoor artificial lighting in the office imitates the standard rhythm of the sun with bright white light in the morning, varying though noon and warm after sundown and the second situation is when the HCL follows the function of the space. Considering the observation that a bluer spectrum light alerts the mind and a warmer CCT relaxes the mind, HCL can be programmed suitably depending on the need for different levels of alertness of the function, may it be a meeting, design work, break times and so on. Situation I, can be implemented by investigating and computing the standard morning, afternoon and evening light levels typical to the region/climate or by having daylight censors, which would be limited to only the parts of the world with sunlight for most of the working day. Situation II, may be designed for a typical workday with an option to manually control the lighting to suit any change in tasks and situations at a workplace.

The Kongsgardmoen School by Kongsberg in Norway uses a comprehensive Human centric lighting (Glamox Luxo Lighting, 2015) using the second technique as stated above. The

school has installed tuneable white LED luminaires that can be tuned from cool white to warm white light in all their classrooms. On arrival at school, a cool white, high intensity light greets the children when they begin their day. The cool white light regulates the production of stress and sleep hormones in the children's and the teacher's bodies. The light thus has an impact on their daily rhythms and shifts it forward, making them much more active during the day. This also has a positive effect on the children's sleep pattern.

During concentration tasks such as mathematics, writing exercise or tests hours the teacher may activate a shower of cool white light and intensive light which increases short-term concentration and alertness. In another situation when the students gather in the front of the classroom to listen to the teacher telling a story or reading a poem, a warm white light creates a relaxed and calm atmosphere. These adjustments in lighting are made by the teacher using standard pre-set controls.

The luminaires used in this setting are modular LED luminaires, which tune the CCT according to pre-defined or manual settings. The colour rendering of the light is high (Ra >90), much higher than the minimum requirements for school lighting. That makes reading, writing and colouring easier and more pleasant. Colour tuning is made easily accessible for the teacher through a wall mounted user panel. (Glamox Luxo Lighting, 2015)

Cool White Light for concentration work (Glamox)

Warm White Light for relaxation (Glamox)

2) **Mimicking Outdoor Dynamism**

The natural outdoors come to ones mind by the thought of sunlight. Sunlight is most experienced outdoor in the constant dynamism of nature. Nature and the outdoor is dynamic on several levels such as the rustling leaves, the moving clouds, the changing light, moving living organisms and so on and all of this experienced in sunlight/ light from the sky. To the human mind, to see the outdoor is to be reminded subconsciously of the sunlight. To a worker sitting indoor, the vision of the outdoor through a window gives them the idea of connection with the same. In a situation where windows cannot be provided, mimicking the outdoors is a possible technique to artificially create one.

From the above case studies in this paper, there have been several instances of such installations such as the daylight installations by Daniel Rybakken and the Philips luminous textile with Kvadrat Soft Cells. These installations are fabricated using multiple LED knit compactly into a screen and dynamically controlled to create patterns to replicate a window. From the corner of the eye, the dynamism that the mind subconsciously feels at the work desk would be similar to the dynamism felt subconsciously by a window at the far end.

The case study of the LED ceiling at Light Fusion Lab at Germany's Fraunhofer IAO Institute replicates a similar phenomenon. In this case the dynamic LED ceiling mimics the moving clouds above the work place. The dynamic movement of the blue and white light/ LED as you see in the case study images would create a dynamic light effect on the work desk and subconsciously on the human eye/mind. The LEDs are intricately placed worked on and chosen carefully to create the full spectrum of the visible light. This technique would work well on a high ceiling. Advancement in this technology is definitely something to look forward to.

Artist named Simon Heijdens recreates a rather creative version of outdoor dynamism in the interiors of buildings such as that in the museum UMNH in Salt Lake City. This 75 sq.m projection covers the canyon shaped central entrance hall of the museum designed by Enead Architects New York, and is a development of the on going work Lightweeds.

These Lightweeds are as dynamic as in real life. They are living digital organism growing onto an indoor space, through which the space regains the natural timeline that it has walled out. Plant families that grow on the walls, move and behave directly depending on actual sunshine, rainfall and wind as measured live by sensors placed outside the building. Along human traffic they bend, loose their seeds and pollinate to other walls throughout the space, to make up a constantly evolving bio system that reveals the character of the space and how it is used. (Heijdens, 2012)

Lightweeds Image1 (Heijdens, Lightweeds Image1)

Lightweeds Image1 (Heijdens, Lightweeds Image1)

3) **Mimicking the physical architecture of skylight**

The Box Experiment shows us that it is possible to imitate skylight with artificial light and the survey showed us that this imitation could be convincing.

In the Model, the two roof types, which were used as examples demonstrate how similar a real skylight and a skylight with artificial lighting, would look. Another model with an interior character was used, and the pictures were shot first in sunlight and then in artificial light. In the survey questionnaire people were asked to identify the picture which had natural light and which had artificial light. A mixed set of people from different professional backgrounds including lighting designers answered this survey and 65% of the respondents believed the artificial skylight to be a true skylight. To an expert, it would be easy to pick the true skylight by the multiple umbrae and penumbra on the wall, also the non-parallel shadows along with the dispersion of light would be an easy give away.

Ideally in an office, as we have already established that the best kind of daylighting is the diffused kind. The direct rays of sun could cause glare and discomfort for a working individual. The constant moving nature of this light also makes the planning and zoning of activities difficult. The placement of computer screens becomes crucial under direct sunlight due to indirect glare caused. Hence the best solution would be to mimic diffused daylight.

Architecturally, best kinds of skylights to mimic are those, which provide a higher ratio of diffused to direct sunlight. As discussed in section 1.4, some skylights allow more direct sunrays than the other. In terms of the feasibility of this skylight module, as per the scaled down model, it would work unto a height of 1m and a proportional width.

These skylight modules would work as ambient lighting in office spaces, which would provide an all round diffused glow, if the right kind of diffuser is used. These modules not

only provide for better quality of light but also encourage a sense of well being by the falsely created connection with the outdoors.

In order to install this particular technique of mimicking daylight, it would be important to design taking into consideration the context and the situation. For instance, at a workspace, an over head box skylight with indirect opening(s) may be used, or a series of saw tooth opening can be used to induce the feeling of openness. In spaces like a narrow corridor which most often are closed from all four side, a clerestory mimicked model may be installed such that an opening of a 300mm height with artificial light at 3 m height above finished floor level, would possibly go unnoticed as an artificial source. In other words, they will have to be case specific.

Also, the other important element to consider would be the kind of lighting. The Correlated colour temperature, the CRI, and the dynamism is an important factor to consider. Diffusers and optics are variables, which may be used differently with different skylight modules.

4) **Use lamps with visible light composition closest to Natural light**

To mimic the compositions of sun's rays would mean to create a black body radiation at the temperature of 5800K. Due to the Nuclear Fusion reactions that take place in the sun, we experience daylight. The intensity of the radiation is also a major factor in how sunlight is experienced by the living beings on this planet.

The spectrum of surface illumination depends upon solar elevation due to atmospheric effects. While the blue spectral component dominates during twilight (before sunrise and after sunset) the red wavelengths dominate during sunrise and sunset. These effects are apparent in natural light where the principal source of illumination is sunlight, which is controlled by the atmosphere. However this happens only during a few minutes in the morning and evening everyday.

Rayleigh Scattering usually determines the colour of the sky, with exceptions during sunset and twilight. When the sun is at the horizon, the zenith sky seems blue due to the preferential absorption of the O-Zone Layer above the atmosphere.(Hulburt, 1953)

The complexity in mimicking the physical properties of daylight is not the only challenge; it is also crucial to consider the subjectivity in human perception of sunlight. As discussed earlier in chapter 1.2, 'Characteristics of daylight', in terms of the spectral composition of light, daylight has the best CRI since it contains all the spectrums visible to the human eye. Artists prefer to work or shoot in daylight due to the best CRI provided by sunlight.

Only when the full spectrum of visible light such as sunlight is incident on an object, the object reflects its truest colours.

The question now arises if a dimmable lamp that has the best colour rendering index and CCT of white light, would suffice to deceive the human mind into believing the existence of a hidden skylight in the space, assuming that the source be hidden.

The light through a skylight is a fraction of the light outside and so is the light required to function or work efficiently. Especially in an office, when the lighting preference is only between 500-800 lux at task level which is a fraction of what daylight can read. Hence it would be effective to have sufficient artificial light sources with a good CRI and chromaticity[6] in the mimicking modules. The perception of natural light colour rendering and appropriate facial modelling contributes to effective worker Interactions.

From the survey analysis, it can be inferred that artificial lights hidden in daylight kind of modules deceived 65% of the respondents. If an additional dimension of mimicking sunlight could be added to the artificial light, by bettering the Colour rendering index closest to that of sunlight, more people would probably be deceived. This is a research question that I believe needs to be studied by involving a wider spectrum of people over different demographics.

[6] Chromaticity-the quality of colour, independent of brightness

4.2 Lighting management

By using lighting management and controls, the ultimate goal would be to obtain effective lighting and maximum energy saving. Good lighting would keep the employees happy while efficient lighting strategies would keep the employers happy.

Ideally in order to have the best balance in lighting, the control system would act firstly, act as per the occupancy censor and secondly by the availability of daylight within the space. However, as per the subject in question, in the absence of an efficient daylighting system, the lighting management system may act around occupancy censors and the mimicked daylight modules. This means that, when mimicked skylight modules would dim down to the natural skylight, the other artificial lighting would have to brighten up in order to achieve sufficient light levels.

The four techniques of mimicking daylight discussed in the paper are as follows;

1. Mimicking CCT properties of sunlight/ Human Centric lighting
2. Mimicking outdoor Dynamism
3. Mimicking the physical architecture of skylight
4. Using lamps with visible light composition closest to Natural light

In order to make these techniques work well in office spaces, they need to be controlled efficiently by good lighting management and control systems.

In the first technique of mimicking daylight, since the sky and daylight are unpredictable and do not have a routine rhythm of specific CCTs nor light levels in a day, it would prove well to have daylight sensors to monitor the light intensity and the chromaticity of light. If the mimicking modules were to act as per these sensors, the other artificial lighting would need to react to these fluctuations to keep up the minimum required light levels. Similarly in the case of mimicking physical architecture of skylight, these modules too will have to be dictated by outdoor sensors. Since these lighting modules act as the ambient lighting in office

spaces, the indirect lighting component in the standard office lighting could be cut down. Generally, daylight sensors only measure lux levels or intensities of natural skylight, however, in this case there is a need for sensors to gauge the CCT of daylight in order to mimic efficiently.

In this scenario of mimicking daylight, the management system for e.g. daylight harvesting, would follow the mimicked daylight modules instead of natural daylight. Daylight harvesting reduces the lighting overheads by reading the ambient light available in the space. It dims down or switches off lighting when sufficient ambient lighting is present or when the space is unoccupied. It also dims individual fittings depending on the distance from the source of ambient light. If this management system is used correctly, it would optimise energy saving and prove beneficial to the office workers.

Therefore, it can be said that the management systems in spaces with mimicked daylight would require two sets of controls and sensors. One for the mimicking modules which need to sense the outdoor conditions and the other set would be utilised by the other artificial lights in the space to adapt to the mimicking modules.

To mimic outdoor dynamism would mean to mimic roughly an outdoor picture and execute it dynamically. It may be the greenery outside or maybe the moving clouds. In this case, in order to mimic windows, the outdoor dynamic picture to mimic would be subjective to the building. It would work better if the dynamic LED panel would mimic a vision similar to the context of the building/ office space. The window modules of daylight mimicry have lesser to do with the artificial lighting inside, since these techniques are more qualitative than quantitative and may not necessarily add to the light levels at the task plane. However the intensity and brightness of these panels would have to relate to the office lighting. The outdoor sensors for this kind of mimicking would have to comprise of a set of complex sensors which detect rains, cloud, sunshine, light intensity and wind parameters. Since these

modules are tucked away in the background of the office environment as a quality enhancer, they could be coupled with multidimensional sensors. As an option the sound system could sync in with the sound of rains or the sound of wind blowing wind.

5.0 CONCLUSION AND DISCUSSION

6.0 Conclusion

At the end of the thesis, it is safe to say that the concept of mimicking daylighting in office spaces has only positive contributions to make for office lighting. Though mimicking daylighting in the absolute sense is not possible, partial characteristics of daylight can be mimicked successfully. This thesis explores the scope in daylight mimicking for office spaces and makes a strong case for the need of further exploration and research in this field. In the survey questionnaire, key thesis related questions were surveyed to 260 office goers and the results prove promising.

The questions required people to distinguish between an artificial module skylight and a natural light skylight. 65% of group were unable to differentiate between the two. This survey also reflected ideas of changing CCT of daylight similar to that of human centric lighting and 245 people out of 260 people supported the idea. This result encourages the need for research and further study into the concept of mimicking daylighting, especially in office spaces.

The subconscious belief of the presence of sunlight above head in a working atmosphere does more good as compared to just an artificial lighting system that provides for comfortable lighting and sufficient light levels. Mimicking day lighting not only improves the quality of light in the space but also makes positive psychological impact on the workers under it.
This thesis has also explored the broad possibility of mimicking the effect of daylighting by simpler techniques rather than intricate and sophisticated installations. These mimicking modules along with greenery in the indoor spaces would create refreshing pockets of desirable spaces. These spaces would be able to break the monotony in office lighting to create a livelier office/ work environment. Also with the right kind of lighting management

and controls systems, an efficient and effective office lighting can be achieved as discussed. Essentially lighting management in spaces with mimicked daylighting would require an intricate dual set of sensor systems; one for the mimicking modules to mimic the outdoor and the other for the standard artificial light to adapt to the changing light levels. In order to not make office lighting boring, the option of mimicking outdoor dynamism could make an office space quite inspiring and joyous. Ultimately it is about improving work-life balance, enjoying the workspace more, and not having a detrimental effect on ones health. This in turn should improve one's productivity and efficiency in the office.

While this concept has a progressive future in the lighting industry and would be beneficial for all spaces away from windows and lacking daylight, this cannot replace natural light. Natural daylight and its benefits cannot be replaced by artificial techniques, however a part of the psychological impact of natural skylight may be induced. The downfall of the overuse of these mimicking modules is the rise of spaces with no daylighting. Spaces with no natural element of light may prove to be extremely dangerous to the inhabitants.

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DIAL. Illustr. 04: Spectral distribution of a blue sky in the morning with a colour temperature of 18 000 K, graphics. *HCL- Human Centric Lighting.* DIAL.

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7.0 APPENDIX

Office lighting Survey (Responses)

Timestamp	What is your age?	What is your work space like?	Do you think lighting in your workplace can influence your mood and alertness?	So you think Daylight is necessary in your work space?	During morning hours of work (8:00AM-12:00PM), would you like to work in Warm, Neutral or Cool lighting? (Please see reference images below)	Which of the following box model images do you think is daylight/natural light?	In terms of keeping you alert post lunch, would you prefer to work under warm, neutral or cool light?	Do you think that it would be beneficial to have adjustable white light (between warm, neutral and cool light) in your workspace through your day?
8/9/2016 23:17:24	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 0:40:00	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 0:45:59	20-35	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 0:47:25	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Both images	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 1:10:39	20-35	Design studio	Yes	Yes	Cool Lighting (6500K)	Image 2	Warm Light (2700K)	Yes, if it is centrally automated.
8/10/2016 1:10:52	20-35	Entertainment studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 1:11:22	20-35	Design studio	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	Yes, if it is centrally automated.
8/10/2016 1:17:27	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 1:23:26	20-35	I don't have a fixed office space	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 1:30:13	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 1:43:15	35-50	Personal Office	Yes	Yes	Warm Lighting (2700K)	Both images	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 1:43:52	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 1:46:40	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 2:48:39	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 4:12:22	50-65	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 5:10:12	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 6:15:42	50-65	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 6:21:03	20-35	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 6:34:23	50-65	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 6:49:10	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 6:54:25	20-35	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, if it is centrally automated.
8/10/2016 7:03:25	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 7:14:13	50-65	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Both images	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 7:25:45	35-50	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 7:32:03	50-65	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 1	Cool lighting (6500K)	Yes, if it is centrally automated.
8/10/2016 7:35:42	65 and above	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 7:35:54	65 and above	Corporate office						
8/10/2016 7:36:12	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, if it is centrally automated.
8/10/2016 7:51:56	50-65	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 7:52:11	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 7:57:46	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.

Office lighting Survey (Responses)

8/10/2016 8:05:16			Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 8:08:18	50-65	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, if it is centrally automated.
8/10/2016 8:34:30	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 8:36:58	50-65	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 8:37:46	50-65	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 8:40:50	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 8:41:42	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 9:02:47	50-65	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 9:03:59	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, if it is centrally automated.
8/10/2016 9:12:53	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 9:17:00	50-65	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 9:17:04	50-65	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 1	Cool lighting (6500K)	Yes, if it is centrally automated.
8/10/2016 9:25:14	50-65	Personal Office	Yes	Yes	Neutral Lighting (4600K)		Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 9:34:12	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 9:37:56	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Cool lighting (6500K)	Yes, if it is centrally automated.
8/10/2016 9:41:15	20-35	Corporate office	No	No	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 9:42:24	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 9:47:04	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 9:50:38	35-50	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 9:50:41	35-50	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 9:51:30	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 9:57:09	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	No
8/10/2016 9:58:32	20-35	I don't have a fixed office space	Yes	Yes	Cool Lighting (6500K)	Both images	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:04:09	35-50	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:05:23	35-50	Corporate office	Yes	Not always	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 10:05:24	35-50	Corporate office	Yes	Not always	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 10:05:25	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Both images	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:06:56	35-50	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, if it is centrally automated.
8/10/2016 10:14:39	20-35	I don't have a fixed office space	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:16:36	20-35	Corporate office		Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:17:30	20-35	Design studio	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:20:48	35-50	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:33:08	20-35	Design studio	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:34:00	20-35	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.

Office lighting Survey (Responses)

8/10/2016 10:35:21	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Both images	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:36:09	20-35	Entertainment studio	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:37:05	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 1	Cool lighting (6500K)	Yes, if it is centrally automated.
8/10/2016 10:39:23	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:39:39	20-35	I don't have a fixed office space	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:40:40	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Both images	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 10:41:57	50-65	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 10:43:05	20-35	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:50:34	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:51:26	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:52:28	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:52:50	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Both images	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 10:56:09	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Neutral light (4600K)	No
8/10/2016 11:03:45	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:04:06	50-65	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:07:10	35-50	Corporate office	Yes	Yes	Warm Lighting (2700K)	Both images	Warm Light (2700K)	No
8/10/2016 11:08:04	20-35	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:08:52	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Both images	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 11:08:54	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 11:10:03	50-65	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:12:35	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 11:14:45	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 11:19:38			Yes	Yes	Cool Lighting (6500K)	Both images	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 11:19:40	20-35	Design studio	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, if it is centrally automated.
8/10/2016 11:20:16	20-35	Corporate office	Yes	No	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:24:51	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:28:57	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 11:34:01	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Both images	Cool lighting (6500K)	No
8/10/2016 11:37:43	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:38:06	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:39:12	50-65	Design studio	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:39:12	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 2	Neutral light (4600K)	No
8/10/2016 11:41:08	20-35	Corporate office	Yes	No	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	Yes, if it is centrally automated.
8/10/2016 11:41:15	20-35	I don't have a fixed office space	Yes	No	Warm Lighting (2700K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.

Office lighting Survey (Responses)

8/10/2016 11:44:40	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:47:27	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Both images	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:50:16	20-35	Design studio	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 11:59:13	50-65	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	Yes, if it is centrally automated.
8/10/2016 12:00:12	20-35	Corporate office	No	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 12:01:22	20-35	Corporate office	Yes	No	Warm Lighting (2700K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:05:12	20-35	Personal Office	Yes	Yes	Cool Lighting (6500K)	Both images	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:07:28	20-35	I don't have a fixed office space	Yes	Yes	Cool Lighting (6500K)	Both images	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:08:24	35-50	Entertainment studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:10:50	50-65	I don't have a fixed office space	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:11:39	35-50	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:12:54	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	No
8/10/2016 12:14:32	20-35	Corporate office	Yes	No	Neutral Lighting (4600K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:20:07	20-35		Yes	Yes	Neutral Lighting (4600K)	Both images	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:20:41	35-50	Personal Office	No	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:23:21	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Cool lighting (6500K)	Yes, if it is centrally automated.
8/10/2016 12:24:26	35-50	Corporate office	Yes	No	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:26:16	50-65	Design studio	Yes	Yes	Neutral Lighting (4600K)	Both images	Neutral light (4600K)	No
8/10/2016 12:31:32	20-35	Design studio	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	No
8/10/2016 12:34:03	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:35:32	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:36:53	35-50	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:37:23	35-50	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:43:45	20-35	Design studio	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:44:14	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:45:58	20-35	I don't have a fixed office space	Yes	No	Cool Lighting (6500K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:48:53	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:53:06	35-50	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:53:48	20-35	I don't have a fixed office space	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:58:41	35-50	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 12:59:03	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 13:01:11	50-65	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 13:12:53	35-50	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 13:14:24	35-50	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.

Office lighting Survey (Responses)

8/10/2016 13:14:25	35-50	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 13:14:51	20-35	I don't have a fixed office space	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 13:15:06	20-35	Personal Office	Yes	Yes	Cool Lighting (6500K)	Both images	Neutral light (4600K)	X
8/10/2016 13:19:44	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Both images	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 13:21:59	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 13:30:36	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 13:45:15	20-35	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 13:47:50	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 13:51:31	35-50	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 13:53:58	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 13:57:42	35-50	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 13:59:45	50-65	Corporate office	No	No	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	No
8/10/2016 14:02:30	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 14:09:18	50-65	Corporate office	No	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 14:13:53	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Cool lighting (6500K)	Yes, if it is centrally automated.
8/10/2016 14:28:20	20-35	Design studio	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 14:38:57	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 14:43:01	20-35	Corporate office	Yes	No	Cool Lighting (6500K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 14:48:19	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 14:48:56	20-35	Corporate office	Yes		Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 14:49:41	20-35	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	No
8/10/2016 14:55:46	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 15:13:45	20-35	Entertainment studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 15:19:22	50-65	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 15:26:54	35-50	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 15:34:45	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 15:36:42	50-65	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 15:46:54	20-35	Design studio	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 15:52:26	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 15:59:15	20-35	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 16:01:56	50-65	Design studio	Yes	Yes	Neutral Lighting (4600K)	Both images	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 16:02:39	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, if it is centrally automated.
8/10/2016 16:11:19	20-35	I don't have a fixed office space	Yes	Yes	Warm Lighting (2700K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 16:11:32	35-50	Personal Office	Yes	No	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.

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8/10/2016 16:15:40	20-35	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	No
8/10/2016 16:30:05	20-35	Design studio	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 16:31:05	20-35	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 16:39:05	35-50	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 17:09:18	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 17:19:08	65 and above	Entertainment studio	No	No	Cool Lighting (6500K)	Image 2	Warm Light (2700K)	No
8/10/2016 17:20:06	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 17:27:06	35-50	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 17:27:27	50-65	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 17:27:55	50-65		Yes	Yes	Warm Lighting (2700K)	Both images	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 17:29:16	35-50	Corporate office	Yes	Yes	Cool Lighting (6500K)	Both images	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 17:35:39	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 17:39:12	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 17:47:39	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 17:51:52	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 17:52:52	50-65	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 17:57:20	35-50	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)		Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 17:58:57	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Both images	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 18:08:23	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 18:10:49	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 18:22:14	20-35	Design studio	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 18:26:41	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 18:42:23	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 18:57:20	20-35	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 18:57:29	20-35	Personal Office						
8/10/2016 19:11:16	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 19:29:58	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 19:58:34	50-65	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 20:21:14	35-50	Corporate office	Yes	Yes	Cool Lighting (6500K)	Both images	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 20:25:46	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 20:29:28	35-50	Corporate office	No	Yes	Warm Lighting (2700K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 20:35:20	35-50	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 20:39:29	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 20:39:28	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.

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8/10/2016 20:43:35		I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 20:53:07	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Warm Light (2700K)	Yes, if it is centrally automated.
8/10/2016 20:58:05	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 21:01:56	20-35	Corporate office	Yes	No	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 21:08:53	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Both images	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 21:11:48	20-35	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 21:18:21	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 21:27:06	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 21:32:54	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 21:45:12	50-65	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 21:50:34	35-50	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	No
8/10/2016 21:52:07	35-50	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 21:52:54	20-35	I don't have a fixed office space	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 21:56:37	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 21:59:23	20-35	Design studio	Yes	Yes	Warm Lighting (2700K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 22:05:37	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Both images	Neutral light (4600K)	Yes, if it is centrally automated.
8/10/2016 22:05:55	20-35	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 22:15:16	50-65	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 22:21:12	50-65	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 22:21:14	50-65	I don't have a fixed office space	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 22:26:21	20-35	Personal Office	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 22:55:51			Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 22:56:20	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 22:56:18	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/10/2016 23:25:13	20-35	Personal Office	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/10/2016 23:28:07	50-65	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/10/2016 23:37:28	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Warm Light (2700K)	Yes, if it is centrally automated.
8/10/2016 23:47:12	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/11/2016 0:02:33	20-35	Design studio	Yes	Yes	Warm Lighting (2700K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/11/2016 0:32:12	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/11/2016 0:36:48	20-35	Design studio		Yes	Neutral Lighting (4600K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/11/2016 1:53:29	20-35	I don't have a fixed office space	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/11/2016 2:18:15	20-35	Corporate office	Yes	No	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/11/2016 2:19:01	20-35	I don't have a fixed office space	Yes	Yes	Warm Lighting (2700K)	Image 2	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.

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8/11/2016 3:32:04	35-50	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Warm Light (2700K)	Yes, if it is centrally automated.
8/11/2016 4:05:04	35-50	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/11/2016 7:48:29	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Neutral light (4600K)	Yes, if it is centrally automated.
8/11/2016 8:26:18	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/11/2016 9:22:48	50-65	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, if it is centrally automated.
8/11/2016 9:58:40	20-35	Personal Office	No	No	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, if it is centrally automated.
8/11/2016 11:29:22	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Cool lighting (6500K)	Yes, if it is centrally automated.
8/11/2016 11:32:15	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/11/2016 12:40:51	20-35	Corporate office	Yes	No	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	Yes, if it is centrally automated.
8/11/2016 14:06:52	20-35	Design studio	Yes	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/11/2016 16:33:37	35-50	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/11/2016 16:42:29	50-65	Corporate office	Yes	No	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/11/2016 22:01:44	50-65	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Cool lighting (6500K)	Yes, if it is centrally automated.
8/11/2016 23:14:50	65 and above	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Cool lighting (6500K)	Yes, I'd like to control my own desk lighting.
8/12/2016 0:18:16	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 1	Cool lighting (6500K)	No
8/12/2016 7:14:26	35-50	Corporate office	Yes	Yes	Warm Lighting (2700K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/12/2016 8:14:42	50-65	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Cool lighting (6500K)	Yes, if it is centrally automated.
8/12/2016 14:49:34	35-50	I don't have a fixed office space	No	Yes	Neutral Lighting (4600K)	Image 1	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/12/2016 15:48:17	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/12/2016 21:42:21	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/14/2016 12:13:13	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Warm Light (2700K)	Yes, if it is centrally automated.
8/15/2016 6:34:55	20-35	Corporate office	Maybe	Yes	Neutral Lighting (4600K)	Image 1	Warm Light (2700K)	Yes, if it is centrally automated.
8/15/2016 11:12:46	20-35	Corporate office	Yes	Yes	Neutral Lighting (4600K)	Image 2	Neutral light (4600K)	Yes, I'd like to control my own desk lighting.
8/15/2016 11:57:58	20-35	Personal Office	Yes	Yes	Neutral Lighting (4600K)	Image 1	Warm Light (2700K)	Yes, I'd like to control my own desk lighting.
8/15/2016 15:11:38	20-35	Corporate office	Yes	Yes	Cool Lighting (6500K)	Image 2	Warm Light (2700K)	Yes, if it is centrally automated.