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THE STUDY OF PSYCHOLOGICAL ASPECTS OF HUMAN CENTRIC LIGHTING

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ABSTRACT

Engineering Psychology is a singular discipline which is however extremely alluring. It is a field of psychology which focuses on the intricate relationship between man and machine, the psychological and human centric aspect behind every innovation and the vitality and exuberance of bridging the gulf between any engineering contraption and its influence on all social animals. This paper is an archetype of a study conducted in this discipline which aims at bringing to light the budding technology of Human Centric Lighting (HCL), its benefits, the psychology involved and its applications in various sectors. In reality, social causes are the driving force for the tech sector innovations and HCL is one of its kind.

Keywords: *Human Circadian Rhythm, Suprachiasmatic Nucleus, Smart Light Source, LED, IoT*

I.INTRODUCTION

Light is a symbol of brightness and prosperity. It is a source of energy that aids our vision. However light is something more than what we see. Good light not only ensures better vision and facilitates better recognition but also does things that are much beyond the visual aspects [2]. In short it can be stated that light has considerable amount of biological effects on human body. It has the ability to influence our emotions, impact our alertness, attention and enhance our concentration, therefore technocrats have tried their hand in mimicking the natural day light in pursuit of enhancing human performance and contribute for better health and wellbeing of human kind. On the whole Human Centric Lighting, abbreviated as HCL aims at providing a holistic approach of lighting exclusively for the wellbeing of human kind [1].

II.PERCEPTION OF LIGHT AND ITS INFLUENCE ON BEHAVIOUR

The Psychology of light:

From a psychological perspective, light plunges into the depths of one's psyche while dealing with the possibilities and limitations of the perceptive skills. It is also said to be the natural equipment of the human psychophysical apparatus which influences one's health and wellbeing throughout life. Light when being analyzed beyond a perspective view point is found to act as a driver of cognitive, behavioral and emotional responses for any perceiver in different experimental contexts of day to day life. Therefore light can be called as

a cognitive map that is able to guide an individual towards exploration of the surrounding environment thereby providing the interpretative keys of a complex reality.

Light – the cognitive map cum emotional device:

Light stimulates one's perceptual apparatus through a type and range of exposure to the light source and its corresponding colors, which is something beyond the defined classical behavioral model of stimulus - response, the emotional adaptation by any perceiver that induces specific emotional states or behavior in the human and the neuro perceptive reaction mechanisms. This specific type of stimulus is capable of the following in order to create a sense of harmony with the surrounding environment. They are;

- excite
- communicate
- impress
- move
- heal and
- generate wellness

Light as a Gestaltic Device:

Based on a psycho – cognitive approach, the environmental cognition which is said to be the basic need of any human being that gives meaning to the surrounding environment by activating the mental process of matching and assimilating the stimuli that comes from an external reality towards the familiar and priorly known patterns which fall within a subject's experimental sphere, allowing to recognize light as one of the most primary factors in the process of mental reconstruction, semantic reappropriation of the environmental space by the perceiver and interpretative decoding. Therefore light is a device that supports the brain's work of setting the syntax of visual perception and reconstruction cum classification of reality by the viewer.

This process of aestaltic reconstruction of the surrounding through light involving both the sensory neural sphere and the individual unconsciousness at the same time, intends to bridge the cognitive gap relating to an unknown reality. This gives human the correct interpretative keys about the outer space enabling them to overcome the primitive and instinctive defense mechanisms against the unknown which determines fear and aggressiveness. Thus light gives meaning to the environment while driving the process of interpretation of reality in order to control the external environment.

III.BIOLOGICAL CLOCK AND THE CIRCADIAN RHYTHM

The circadian rhythm is a 24 houred internal clock that runs in the background of our brain. It cycles between alertness and sleepiness at regular intervals. It can also be termed as the sleep – wake cycle. A part of the hypothalamus in the brain is said to control the circadian rhythm. Light is an external factor that has great impact on it. This is driven by the biological clock. Our human body has several internal clocks that are mere

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clusters of interacting molecules in cells present in our body. The master clock present in the brain coordinates with all the other trivial clocks so as to keep them synchronized. It comprises of a group of nerve cells in the brain called suprachiasmatic nucleus (SCN), which is said to contain about 20,000 nerve cells located in the hypothalamus, above this the optic nerves from the eyes cross the brain.

The biological clock composed of genes and proteins are made to operate in a feedback loop. These genes contain instructions that make clock proteins whose levels are seen to raise and fall at regular cyclic patterns. This influences the circadian rhythm. These biological clocks are capable of resetting themselves, which is the key concept for the inception of HCL.

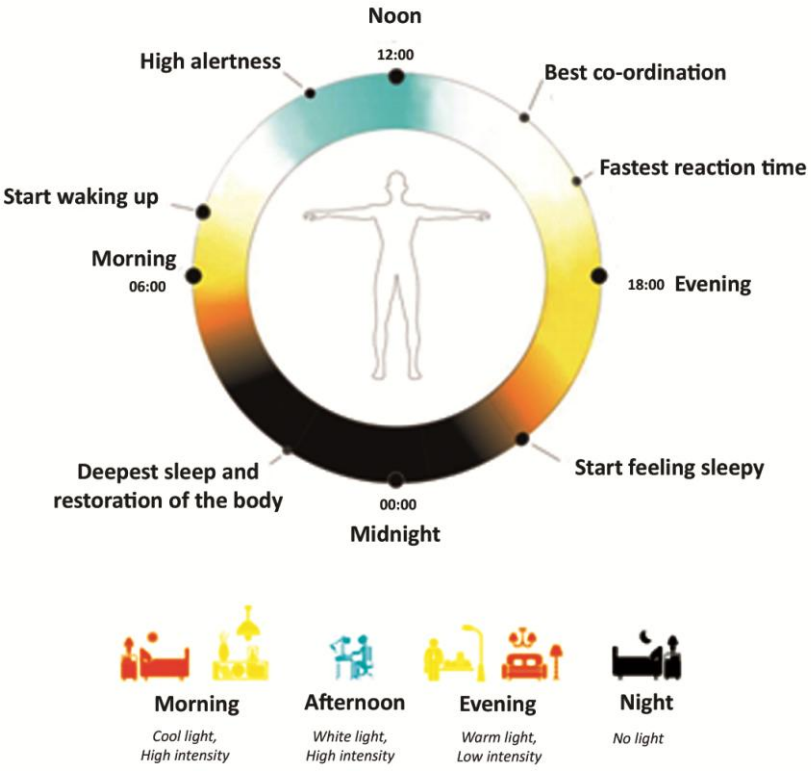

Fig.1: The human sleep-wake cycle (courtecy:www.ee.co.za)

Influence of the circadian rhythm on bodily functions:

This circadian rhythm has influence on various bodily functions, emotional and psychological conditions. It has its impact on hunger, metabolism, alertness, fertility, body temperature, hormone release etc., several studies have proved that Human Centric Lighting has several positive effects on cognitive functions thereby facilitating sustained attention, enhanced performance, reduced error rate and improved memory functions.

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Impact of light on circadian rhythm and sleep

Light is the most powerful synchronizer of the human circadian clock. As light enters the human eye, signals are sent from the retina to the brain's visual nerve center and the SCN, thus influencing the master clock and thereby he circadian cycle. Certain cells in the retina called the ganglion cells that are not used for vision purpose are extremely sensitive to visible blue light, in turn setting the biological clock which synchronizes the human body with external day – night cycles.

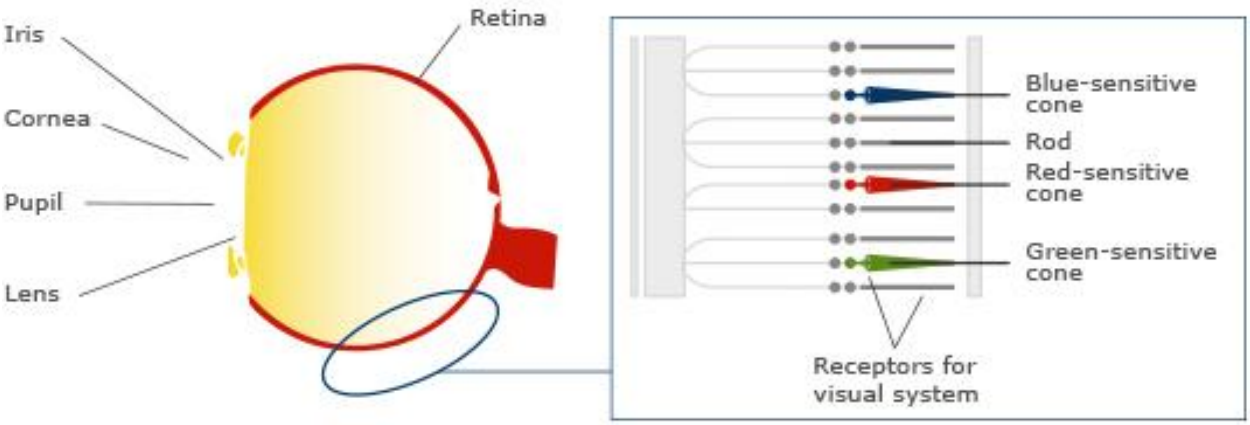

Fig.2: Anatomy of human eye picturising light sensitive cones (courtecy:glamox.com)

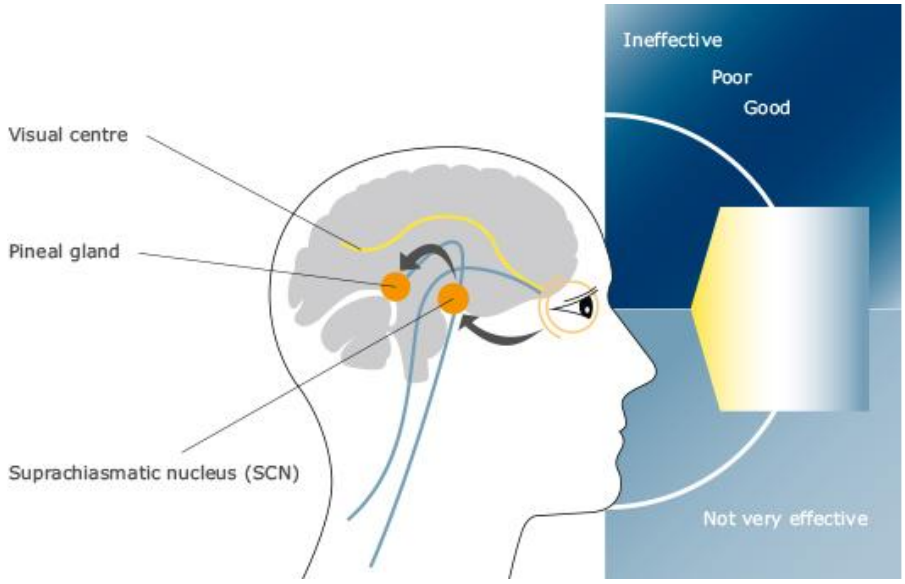

Fig.3: Anatomy of human brain picturising suprachiasmatic nucleus (courtecy:glamox.com)

The timing of light exposure during the course of a day is responsible for the way in which the circadian clock is synchronized with the environment. Consider the following case;

- Late evening light exposure delays circadian rhythms resulting in late sleep and wake times
- Early morning light exposure advances circadian rhythms resulting in early sleep and wake times

The ganglion cells are also found to regulate hormone production by sending signals to the brain. Cortisol, which is called as the stress hormone that is usually produced during the early hours of a day stimulates metabolism. Serotonin acts as a stimulant that elevates the energy levels, working during peak hours, while melatonin which is also called as the sleep hormone causes sleepiness and make us feel tired [4]. Thus tuning the brightness of the light all along the day according to the need will effectively help controlling these hormone production thereby fine-tuning our emotions, hence enhancing productivity.

IV.HUMAN CENTRIC LIGHTING – AN ART AND ARTIFACT

According to LEDInside, Lighting Europe has defined HCL as that type of lighting which would benefit both biological as well as emotional health of a person by dimming the smart light source (the LED) to mimic the sunlight's intensity levels all throughout the day.

Fig.4: Tuned light from smart light source (courtecy:google.com)

The Psychophysics of HCL:

Sensation is defined as the ability of an organism to become aware or conscious of the stimulus present in the internal or external environment. This awareness or consciousness has two aspects, one concerned with the problem of detection while the other concerned with the problem of discrimination.

Each sense organ is specifically stimulated in order to produce a particular kind of sensation by means of the physical energy that a particular kind of stimulus emits. For instance the eyes are stimulated by the light producing the sensation of vision. One may or may not at all have seen a light in a particular area. The question arises as to how much sensory stimulation is needed for producing a given sensation. This question of detection or discrimination is answered through two technical concepts namely absolute threshold and differential threshold.

Absolute threshold is defined as the minimum intensity of physical energy of a stimulus that may produce any sensation at all in a person. It does not mean that below a certain intensity of physical energy, a stimulus is not able to activate the receptor of a sense organ. The receptor of the sense organ is always activated or stimulated but the stimulation may not be strong enough to result in a sensation. The question of discriminating between

stimuli or finding difference in sensation may be answered in terms of differential threshold and more clearly through weber's law.

The differential threshold is the minimum difference in the intensity of two stimuli that a person is able to detect. In other words, it is the smallest change in stimulation that he is able to detect or the smallest difference in sensation the individual is able to discriminate. This is also named as just noticeable difference j.n.d. the differential threshold like absolute threshold varies from individual to individual.

Weber's law: This law states that the differential threshold is proportional to the strength or value of the stimulus. It means that for creating just a noticeable difference we have to increase or decrease the intensity of the stimulus in the ratio of the strength of the stimulus.

V.THE TECHNOLOGY BEHIND HCL

It is known that certain attributes like glare control, contrast sensitivity, uniformity and luminance define the light quality. The HCL technology is a wireless lighting technology that exploits the virtue of sensors and software for making people's lives convenient and simple. This energy efficient technology makes the LEDs to sense and locate where there is need for light and accordingly determines the color and intensity. These smart lighting devices are all associated with a centralized lighting control system.

Philips is the giant industry that is mastering in HCL Technology [4]. They connect all these smart light sources into an IOT (Internet of Things) which is in turn paired with PoE (Power over Ethernet) which allows carriage of electric current through data cables rather than power cords. This makes the AP (Access Point) installation more flexible and easy, particularly on ceilings. Thus as the ethernet cables carry data from and to the light sources, the operators and the building occupants are allowed to control the system intelligently through their internet connected PCs (Personal Computers), smartphones etc., remotely or onsite.

Fig.5: Smart Lighting with IoT (courtesy: lighting.edu)

It is known that dimming technology is being available for commercial spaces since long; where the level of lighting would be altered by adjusting the fixture's power circuit. However the future of smart lighting would be embedding the control capability inside the LED's driver circuit with the help of digital protocols, which communicate with the drive's circuit directly.

The target is not just adjustment of the light intensity but also the color rendering and color quality defined by the correlated temperature. Bringing HCL into buildings refers to installing tunable fixtures along with smart lighting controls that could control both intensity as well as CCT. Usage of a scheduling device which would automatically synchronize the building's lighting cycle to that of astronomical event timings, thereby matching with the exact lighting conditions outside the building based on accurate latitude and longitude measurement of the particular location.

VI.HCL IN HEALTHCARE CENTERS

Human centric lighting aims at improving people's efficiency in the working environment therefore it can also be termed as ergonomic lighting. In an effort to improve the environmental conditions for the patients, nurses and physicians and create a better ambience this ergonomic lighting is intended to be implemented in hospitals. By combining the colors of red and green and by dividing the room into different color zones based on the tasks the effectiveness of the lighting is experienced. It results in less strain on the eyes, reduced stress and improved quality. The effective combination of these complementary colors offers a balanced lighting of the room while eliminating reflections on the monitors.

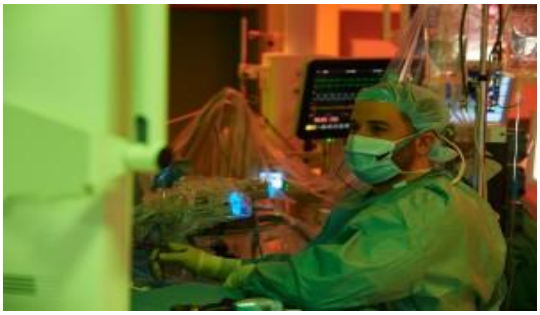

Fig.6: Ergonomic lighting in operation theater at Central Hospital Karlstad, Sweeden (courtesy: chromaviso.com)

This lighting concept is found to support the natural circadian rhythm of both the patients as well as the staff, which extremely challenging especially during night shifts. At mornings the light keeps raising so that the patients could wake up along with the light while at nights the light gives a soothing feel keeping everyone calm.

Fig.7: Light in synchronization with circadian rhythm (courtesy: chromaviso.com)

Fig.8: Ergonomic lighting in patient room (courtesy: google.com)

Fig.9: Ergonomic lighting in intensive care unit (courtesy: glamox.com [5])

VII.HCL IN EDUCATION

Education institutions, especially Schools are excellently suitable for tunable white light features, where light is not only used to control circadian rhythms for pupils and tutors, but also to improve alertness and concentration. In the mornings the right light with sufficient brightness and blue-enriched, helps one get ready for the day. Here the change in intensity and color temperature is automatic, but they could also be dimmed using control switch in the classroom [7]. Especially in education, a conscious mind is vital for good concentration during the lessons. It doesn't matter if the person is an elementary scholar or a teacher. Both can benefit from an optimized lighting environment in a direct or indirect way.

Fig.10: Human centric lighting in Lindeborg school, Malmo City
(courtesy: http://lightingforpeople.eu)

Fig.11: Human centric lighting at school
(courtesy: glamox.com [5])

VIII.CONCLUSION

This paper discussed about the significance of light, the influence it has on human emotions and bodily functions and how tuning of its brightness and color temperature could increase productivity in consumers. It also discussed in detail the concept of Human Centric Lighting and the technology involved in it along with pictoric evidences from case studies. It could therefore be concluded that HCL is a promising technology that would very soon be implemented anywhere and everywhere in the near future.

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