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A STUDY ON THE EFFECT OF LIGHT SOURCES ON THE COLOUR OF OBJECTS

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ABSTRACT

Lighting is one of the basic aspects that eases our lives and increases its quality. We use lighting tools in many places such as homes, streets, work places, hospitals, factories, etc. In this study, the effects of the light source and the surface of the object on features like colour temperature, glare, colour (perceived) and dominant wavelength is analysed. Four light sources such as a warm white halogen lamp, warm white LED source and two cool white LED sources were used. In the light measurements, 10 paper surfaces and 8 cloth surfaces were selected as the surface type. Colours of the surfaces were selected among the main colours on the colour locus. Light, reflected from surface was recorded with Konica Minolta CS-200 model. All results were indicated and compared with each other.

Keywords: colour temperature, glare, colour (perceived), dominant wavelength

1. INTRODUCTION

Light is a special form of energy, which spreads as wave and acts as a particle; hence, it is explained with photon and wave theories. Both theories complete each other and explain two different features of light energy [1].

The term colour can be described as the effect of light that is left in our eyes after the light has hit and reflected by bodies. When it comes to the colour concept, it is essential to define the groups of rays having different wavelengths and reaching different hues, saturations and values within their physical boundaries. The colour has its value in accordance with the light it reflects; the same colour family has its hue that differs in terms of value and saturation, yet depends upon the colour gradation with close associations. Moreover, it has saturation in accordance with visual intensity and purity. In order to have a proper sense of colour; a light reflected from the object, a healthy eye functioning according to the incoming light and also a perfect visual cortex in the brain are necessary. The eye transmits the wave vibrations to brain via colour nerves and so the colour is recognized [2]. Briefly, while the light coming to the eye is a physical event, processes in the eye are physiological, and finally the perception of the rays in the eye is a psychological event. Most of our sensory interaction with surround surfaces is based upon our visual perceptions comprised of light and colour stimuli. Colours are emerging because of light frequencies intensity have an impact on human psychology and actions through their low or high energies vibration. Psychological effects of colours influence human’s mental activity, physical performance, and psychosocial state; hence, it has a key role on the human- equipment- surface system [3]. Lighting means applying the light in order to render objects and surface visible. Lighting design is an art and science branch that describes the relationship between the place and the user by using light tools. Lighting is the most important complement for the value and atmosphere of the place.

In his study, Duran [2] has called attention to the role of colour on the ergonomics searching the nat-

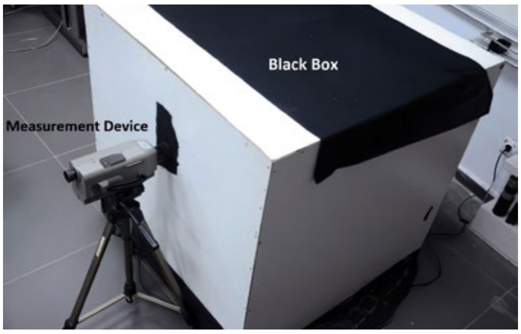

Fig. 1. Measurement device and black box

Fig. 2. Measurement device position

ural and technical rules of the relationship between objects (used by people) and the surface (inhabited by people). The importance of colour, which evokes people's physical and psychological perceptions, is emphasized in terms of individual- object- surface accordance. Duran analysed the colour applications and effects in different styling realms in the context of colour's psychological effects and application. Consequently, he emphasized colour's key role on the ergonomics as a psychosocial factor affecting the colour perceptions, motivation, attention, communication, creativity, etc. He also demonstrated that colour is an important factor for improving the working conditions, humanizing the workplaces and maintaining human surface accordance [4].

In their research, Ceken and Yıldız [5] have investigated the effect of colours on advertisement perceptions. They stated the importance of colours on the effect of advertisements and consumers' preferences. Colours, encouraging our perceptual organization, evoke the senses by helping customers to know the property and the service they are about to buy. These imprinted advertisements were analysed in sense of colour dimension and the authors tried to prove that different colours have different characteristics [5].

Colours physical and psychological effects turn their form into a structure giving a message themselves and play a key role in the perception of advertisements. In this research, the effect of natural and artificial light sources on the light reflected from the surface in the different coloured and different reflecting surfaces is analysed in laboratory.

2. MATERIAL AND METHOD

The research was carried out in the high voltage laboratory of the Engineering Faculty of Istanbul University-Cerrahpasa. Experimental setup of the research is illustrated in Fig. 1. A light-tight box within the size of 1 m×1 m×1 m was designed and built for the experiment. The inner part of the box was covered with a black, non-reflecting and light absorber coating [6, 7]. Two holes, 4 cm in diameter, were opened in the middle of the top and middle of the side surface of the box. While the hole on the top surface was opened to place the light source, the other hole located on the side was used to place CS-200 Colour and Luminance Meter (Fig. 2). Another device (Chroma meter CL-200A) seen in Fig. 3 is placed in the light-tight box. After both devices were situated on the holes, it was assured that holes were light tight and then measurements were carried out.

The placement of the test objects is shown in Fig. 4. During the experiments the distance in Fig. 4 is the same for all test objects either paper or cloth as shown in Fig. 4.

Colour and Luminance Meter is situated across the midpoint of the test object with a distance of 100 cm.

Objects to be measured were selected in different colours and surfaces. During the experiments, 10 different colour of A4 paper of 80 gr/m^2 and 8 different colours of cloth (pile height: 2 mm) made of the same material were used. In order to make precise and accurate measurements and hence analyse the effect of the surface structure, attention was

Fig. 3. Chroma meter CL-200A

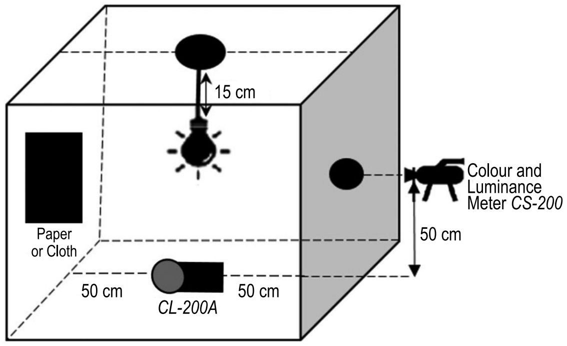

Fig. 4. Placement of the test objects

Fig. 5. Paper colours

paid to choose similar colours for papers and cloths [8]. Types of different papers and clothes fabric are showed in Figs.5,6, and surface comparison blue cloth and paper in Fig. 7.

Four different light sources were used during the research: a 75 W halogen bulb, a 9 W- warm white LED bulb, a 3 W- cool white LED bulb and one 5 W- cool white LED bulb. The aim of the selecting these light sources is to compare the formerly widely used halogen lamps with LED sources, which are now very popular and whose usage area is expanding rapidly. In addition, LED sources, which have different power ratings, are used to compare the effect of light intensity. However, the most important purpose of the study is to observe differences between the light sources and daylight. Data obtained through the experiments were compared with those obtained in daylight. The characteristics of the light sources used in the study are shown in Table 1.

As luminance glare were measured in the range of (0.01–200,000) cd/m^2, the sensitivity of the device was set to 1 degree. To define the effect of the light source on the correlated colour temperature of the light reflected over the test equipment, UGR, colour and dominant wavelength were measured and illustrated in Figs. 6–11. After analysing these figures, the most appropriate surface conditions for the human eye were evaluated with reference to daylight. Daylight measurements were taken afternoon 05.05.2017 (16:00) at the location of latitude: 40^o 59′ 19.70″ N, longitude: 28^o 43′ 30.01″ E; altitude: 81 meters, solar azimuth: 262.50^o and solar elevation angle: 32.81^o.

3. EXPERİMENTAL RESULTS

Following the experiments, graphs of the research data were shown in this section. Six different graphs were prepared in such way that all light equipment used for paper and cloth surfaces were compared in terms of different light characteristics. In addition, different graphs were arranged to compare rough and smooth surfaces [9]. The aim of this study is to compare the features of a fixed lighting object with the light reflected by different surfaces. In these experiments, light source greatly affected the feature of the light reflected from the cool white.

In graphs Fig. 6 and Fig. 7, the dominant wavelength (in nm) of the lights reflected from the material with different colours was measured under different types of light sources. While graphs Fig. 6 shows the dominant wavelength of reflected lights for the paper, graphs Fig. 7 demonstrate results for cloth surface.

Fig. 6. Clothes fabric colours

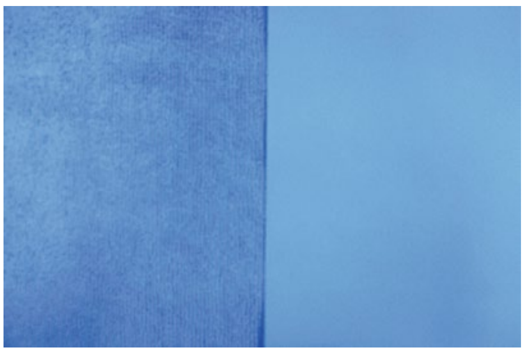

Fig. 7. Surface comparison of blue cloth and paper

Table 1. Lighting Sources Types

TYPE of SOURCE	LIGHT COLOUR	CORRELATED COLOUR TEMPERATURE, K	LUMINOUS FLUX, lm	LAMP MARK
HALOGEN	WARM WHİTE	2700 K	980	FUJIKA
LED3 W	COOL WHİTE	6000 K	240	BENAR
LED5 W	WHİTE	5700 K	350	LAMPTIME
LED9 W	WARM WHİTE	3000 K	900	AKIWA

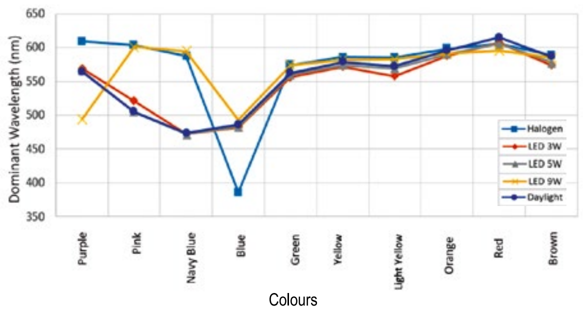

Fig. 8. Dominant wavelength-colours on papers

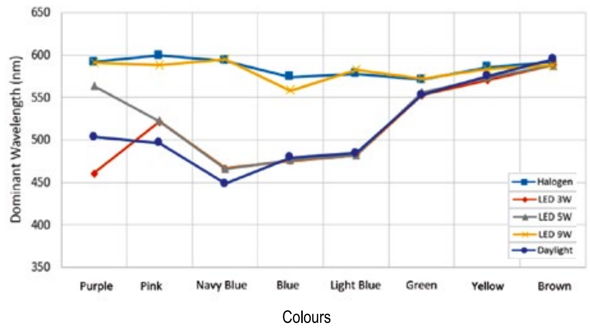

Fig. 9. Dominant wavelength-colours on cloths

Graphs Fig. 8 and Fig. 9 shows that the dominant wavelength of the reflected light is varied between 450 nm – 500 nm in the range from purple to green under the cool white light, however**,** when it comes to warm white light, it has greater values 550 nm – 600 nm for the same range. At this point, the results indicate that in defining the dominant wavelength of the reflected light (especially for low temperatures of light, such as 3000 K or less), the light source type is more effective than the surface colour of the material [10].

Graphs Fig. 10 and Fig. 11 demonstrates that, as dominant wavelength data, the light object used in surfaces capable of reflecting light in warm white and greater dominant wavelengths does not change in the dominant wavelength of the light reflected from such surface. It is possible to conclude that on green, warm white or brown surface, the colour and illuminance levels of light sources have not any significant effect on defining the dominant wavelengths [11]. In the spectrum, it was observed that it would be useful to prefer cool white light sources (applied in this work LED3 W and LED5 W) for the outcome to be close to daylight in surfaces capable of reflecting light dominant wavelengths which are purple, pink, navy blue, blue and light blue.

For the paper surfaces, five lines representing the different light sources, including daylight in Fig. 10. As it can be seen on the graph, the temperature value changes from 2000 K until 18000 K.

Fig. 11 also shows the correlated colour temperature according to reflected light from various surfaces, however in this case cloth is used as the main surface material.

All correlated colour temperatures of the light reflected from the surfaces were measured with ref-

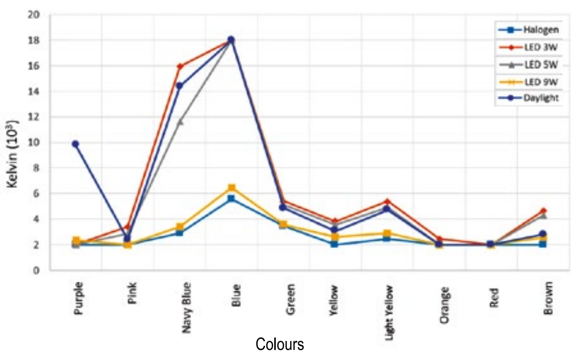

Fig. 10. Paper colour – correlated colour temperature

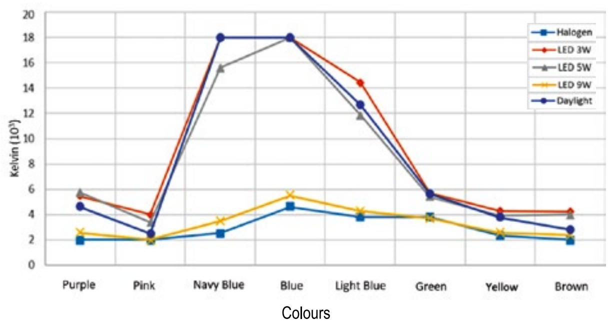

Fig. 11. Cloth colour – correlated colour temperature

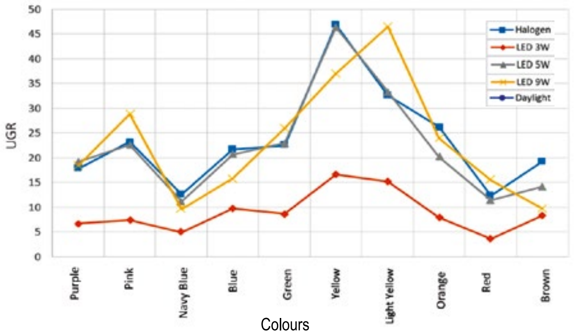

Fig. 12. Glare lines on paper

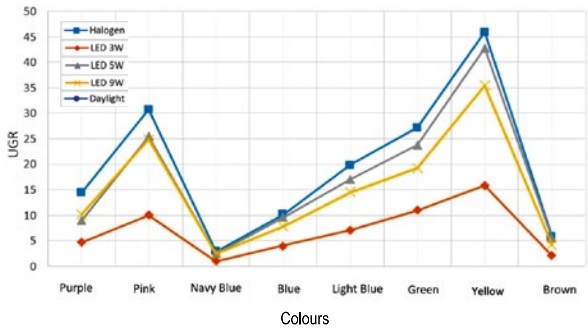

Fig. 13. Glare lines on cloth

erence to daylight rates. According to the results, correlated colour temperatures of dark blue and blue surfaces are is the highest among all lighting equipment. According to Fig. 10 and Fig. 11, external light sources do not have any major effect on the reflected correlated colour temperature of light when used in surfaces with the surfaces outside the pink-green range.

The International Commission on Illumination (CIE) identified the unit of glare as Unified Glare Rating (UGR). The UGR is a ratio of light source luminance and background luminance [12]. Fig. 12 and Fig. 13 clearly indicates that all type of lightning objects have the highest glare values on warm white surfaces.

For any colours paper type surfaces there is a huge difference between the glare values of 3 W LED source and daylight. Similar tendency is also observed on cloth surfaces as seen in Fig. 11. However, UGR values at different surfaces colours are not the same as measured on paper surfaces.

Also according to Fig. 12 and Fig. 13, the lowest glare rating values are obtained in purple- navy blue and red-brown surfaces, in which the light reflected from all of the lightning equipment has close values.

This study aimed to differences revealing between both of the used surface types illuminated with different light sources. When it comes to analysing dominant wavelength in paper-cloth comparison, graph process was "ruined" in blue paper surface.

4. CONCLUSIONS

In this study, by using different light sources, waves reflected from mainly two different material groups, such as cloth and paper were examined for various surface or colours of this surfaces.

The study revealed us clearly that the human eye can function much more conveniently and smoothly if lightning equipment with close parameters to daylight are chosen. Colour of the surface has a great effect on the feature of the light coming to an eye. Hence, it would be beneficial to use warm white hues for living spaces.

In addition, within this study, the change in dominant wavelengths (of several colours) over time has been measured, and the importance of colour concept has been emphasized, which allows the objects to be clearly seen and distinguished. Comparative analyses of similar sources are made by measuring individual dominant wavelengths for each of lighting sources.

The study revealed us clearly that the new generation sources provide a sharper vision and, in order to get an optimum vision for each surface colour, the type of the lightning equipment should be selected carefully according to several application parameters.

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