iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** XI **Month of publication:** November 2021

DOI: https://doi.org/10.22214/ijraset.2021.38921

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XI Nov 2021- Available at www.ijraset.com

Investigation of Photometric Flicker Phenomenon Effect on the Perception Level of Office Workers in Different Age Groups

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Abstract: ***Today, under the conditions where the number of office workers and artificial lighting applications have increased, although the effects of the Photometric Flicker phenomenon are serious, it is an issue that has not been understood in detail and people are not aware of it. Photometric Flicker phenomenon, which is a direct result of using ballasts or drivers with low power factor and lacking the necessary filtering features; It causes results such as decreased visual performance, loss of attention and perception. Considering that the conversion of LED luminaires is still not completed in many office buildings in the country, it is seen as an important requirement to investigate the Flicker effect in interior spaces that are considered to offer similar lighting levels and conditions, and to make a concrete due diligence by correlating this with the average age of office workers. For this reason, in this study, various tests and experiments were carried out with volunteer participants aged 18-30, 31-45 and 46 years of age and older without any significant vision problems, and the outputs of these studies were aimed to shed light on the relationship between age and lighting conditions.***

Keywords: Photometric Flicker, Interior lighting, Age and lighting relationship, Disruptive effects in lighting

I. INTRODUCTION

With the advancement of technology, the number of office workers has increased significantly compared to the number of workers in the production and maintenance areas. Many different jobs and tasks that require attention and high perception are performed at desks and/or computers in offices. Studies on the mental and physical conditions of office workers who spend a long time indoors and cannot benefit directly from daylight have shown that the resulting effects range from loss of workforce and making critical mistakes [1-3]. For an efficient work area lighting application, both meeting vision needs and continuity in lighting come to the fore as an important requirement.

Since the effect of the photometric Flicker phenomenon strikes the mentioned continuity, it can cause physical and psychological problems such as the desire to leave the interior volume, eye strain, and headache [4].

In order to prevent the aforementioned problems, dynamic lighting based on daylight or imitating daylight, applications in which different scenario applications or automatic and/or manual dimming are possible have recently been used globally [5,6]. However, although it is a well-known fact that the effect of Photometric Flicker on people increases when it comes to dim control, regardless of the light source used, it has become a seriously discussed situation that unpredictable results occur. Perception problems and mistakes in the work can be given as examples.

In order to reveal the numerical values of the flicker effect, the following graphs and formulas are used (Figure 1). As a result of percentage Flicker and Flicker index calculations, a comment can be made on the lighting quality of the lighting equipment. While the Flicker index ranges from 0 to 1, the Flicker percentage can be up to 100%.

In the use of fluorescent lamps with electromagnetic ballasts, the percentage of Flicker increases up to 100% in 100% operation, while in operation with electronic ballasts, this percentage can decrease by 70% depending on the characteristics and brand of the ballast. Within the scope of this study, in 3 different office environments – with fluorescent fixtures and electromagnetic ballast (Room 1), with fluorescent fixtures and electronic ballast (Room 2), fully LED fixtures (Room 3) – office workers of different age groups were assigned various tasks in different lighting scenarios. The level of success in their realization was investigated. In addition, a survey was prepared to investigate the psychological states of the people who participated in this experimental study during the time they spent in the rooms they were in. Thirty subjects aged 18-30, 31-45 and 46 years of age and above, 15 males and 15 females, without any significant vision problems, voluntarily participated in this study. There are 5 male and 5 female subjects in each age group. Volunteers participating in the experiment made their notifications in a total of 5 different lighting scenarios in a room by means of a survey.

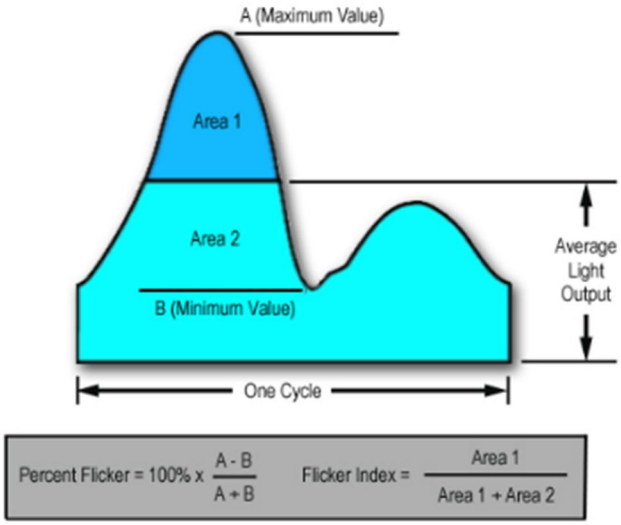

Fig 1. Photometric Flicker percentage and index calculation methods [7]

II. EXPERIMENT, SURVEY AND RESULTS

The rooms are located on the 3rd floor of the 4-storey Sakarya University Engineering Faculty building, M-6. The exact coordinates of the rooms are 40º 74' north latitude and 30º 33' east longitude. The surface area of the rooms is 24 m2 and each room has 1 window facing north-west. The artificial lighting systems of Room 1 and Room 2 consist of 6 luminaires with 4*18 fluorescent lamps and double parabolic mirror shutters. Electromagnetic ballasts are used in luminaires in Room 1 and electronic ballasts are used in Room 2. In Room 3, 1*41W 6 pieces of 60cm*60cm DALI ballast (92% eff, pf=0.95) middle class LED panels are used. Room 3 also has a dimming feature. Images of the rooms are shared below (Figure 2-3).

The participants, who participated in the survey study voluntarily in the experimental rooms, were left alone in the rooms for 10 minutes each to get used to the rooms, and then the participants were given the Visual Burdon Tests, which lasted for about 2 minutes. The Burdon test is a test for finding a specific letter or image without errors in mixed letters and visual sequences, which is used to measure the attention and perception level in children and young people. It has been determined in the literature research that the Burdon tests are still being used and it has been decided to use them in this study as well. Tests in rooms 1 and 2 with 100% work and room 3 with 75% work were evaluated together. A different Burdon test for Room 3 was also given to the participants for the 100% and 50% levels. After the completion of these tests, the participants were asked to fill in a second survey that determined their psychological approaches to the rooms they were in.

Fig 2. Fluorescent Luminaire Layout for Room 1 and Room 2

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XI Nov 2021- Available at www.ijraset.com

Fig 3. LED Luminaire Layout for Room 3

When Table 1, where the parameters are given for the rooms in question, is examined, it is seen that the brightness levels of 100% working in Rooms 1 and 2 and 75% working in Room 3 are close to each other. For this reason, a separate Burdon test was applied for these 3 and a separate Burdon test was applied for the other levels in Room 3. The illuminance values in the table are the values taken with the TES 1336A luxmeter and the Flicker values with the UPRTEK MK350 measuring device on the working plane at a height of 80 cm from the ground.

As can be seen, the worst Flicker percentages and indices were observed in the use of fluorescent luminaires with electromagnetic ballast, and the best values were obtained in the use of DALI ballast LED luminaires without dimming. The biggest reason for this is that the DALI ballast is also an electronic driver circuit and the LED light sources work at the correct voltage with power factor correction. The reason why Flicker percentage and index increase after dimming in Room 3 is that DALI ballasts driving with PWM modulation clip the correct voltage waveform at certain rates due to the dimming ratio. If a driver/electronic ballast without dimming feature was used instead of DALI ballast, Flicker values could be expected to increase even more.

The attention tests and surveys applied to the participants were carried out during the hours when there was no daylight effect and when it was dark. When Tables 2 and 3 are examined carefully, it is seen that the success in the attention test in Room 1 and Room 2 with high Flicker percentage and index is even lower than the situation in the least illuminance level and the highest Flicker values in Room 3. As the percentage of flicker increases, it can be easily understood that distortions in perception occur and distraction occurs when looking at the results obtained from all 3 rooms and only when looking at the 3 different lighting scenarios of Room 3.

Table 1
Parameters for Rooms

Room Number	1	2	3		
Dimming	100%	100%	100%	75%	50%
Illuminance Level (lx)	226	228	427	241	130
Flicker Percentage	91%	66%	9%	24%	62%
Flicker Index	0,49	0,21	0,02	0,07	0,19

Table 2
Burdon Test results under similar illuminance levels in 3 rooms

Room Number	1	2	3
Dimming	100%	100%	75%
Success between ages 18-30	86%	89%	91%
Success between ages 31-45	83%	85%	90%
Success over age 46	78%	81%	86%

Table 3
Burdon Test results under different illuminance levels in Room 3

Room Number	3	3
Dimming	100%	50%
Success between ages 18-30	93%	90%
Success between ages 31-45	91%	87%
Success over age 46	87%	83%

Table 4
The Feelings of the Participants Regarding the Lighting Conditions in the Rooms

Room Number	1	2	3		
Dimming	100%	100%	100%	75%	50%
Feeling uncomfortable in the room	12 p.	7 p.	1 p.	2 p.	3 p.
having a focusing problem	12 p.	8 p.	1 p.	2 p.	5 p.
Not want to work for a long time in the room under current conditions	15 p.	10 p.	1 p.	2 p.	6 p.

Examining for age ranges, it is understood that visual performance in the 18-30 age group is the highest in the scenario with the lowest Flicker percentage and level under similar conditions, and there is a decrease of up to 8% in perception and attention when the age level increases. For all 3 test rooms, it is seen that the young people have a higher level of attention and perception under the same lighting conditions than the older ones. The findings obtained with the 8-question survey conducted in order to understand the psychological state of the participants during the time they spent in the rooms are given in Table 4. 8 questions were evaluated by reducing them to 3 main headings.

When the results shared above are examined, the number of people who complain about "feeling uncomfortable in the room" and "having a focusing problem" increases dramatically in cases with high Flicker-related values. Especially in the age group of 46 and above, 8 out of 10 people declared that they had problems focusing in Room 1. If we talk about room 3 in particular, the fact that the brightness level is low at 50% working level as well as the increase in Flicker values is thought to be one of the important sources of the focusing problem. The number of people who do not want to work for a long time in the experimental rooms under lighting conditions with high Flicker-related values also shows how discriminating the Flicker effect is in offices. Among the 18-30 age group participants, only 1, 4 in the 31-45 age group stated that they did not want to work for a long time in Room 1, which has the highest Flicker effect, while all of the 46 and older participants stated that they felt uncomfortable in this regard and did not want to work in the room for a long time.

III.CONCLUSION

In this study, it has been tried to investigate the effect of the Flicker effect caused by lighting equipment with different characteristics on the perception of office workers who have to benefit from artificial lighting, by considering their age as a factor, short-term exposure to different lighting conditions, attention test and survey methods. In this context, 30 volunteers from different age groups took part in the experiments.

In the evaluation made in the light of the answers they gave to the attention tests and surveys, it was seen that the perceptions of the people who work in conditions with a high Flicker percentage and index are low, especially as the age progresses, the level of perception decreases even more, the older workers have high concentration problems and they do not want to work for a long time in the current conditions. .

In dimmed scenarios, it has been understood that people experience perception and focus problems as the dimming level increases, although the rate varies according to the age groups of the employees. It has been concluded that vision problems increase as the age of the employee increases, lighting equipment with low Flicker values should be preferred in order to avoid focusing and attention problems, and it would be beneficial to prefer drivers with high power factor and Flicker filter. Obtained results and outcomes comply with similar studies held before [8] and draws a new path to us in selecting and projecting interior lighting.

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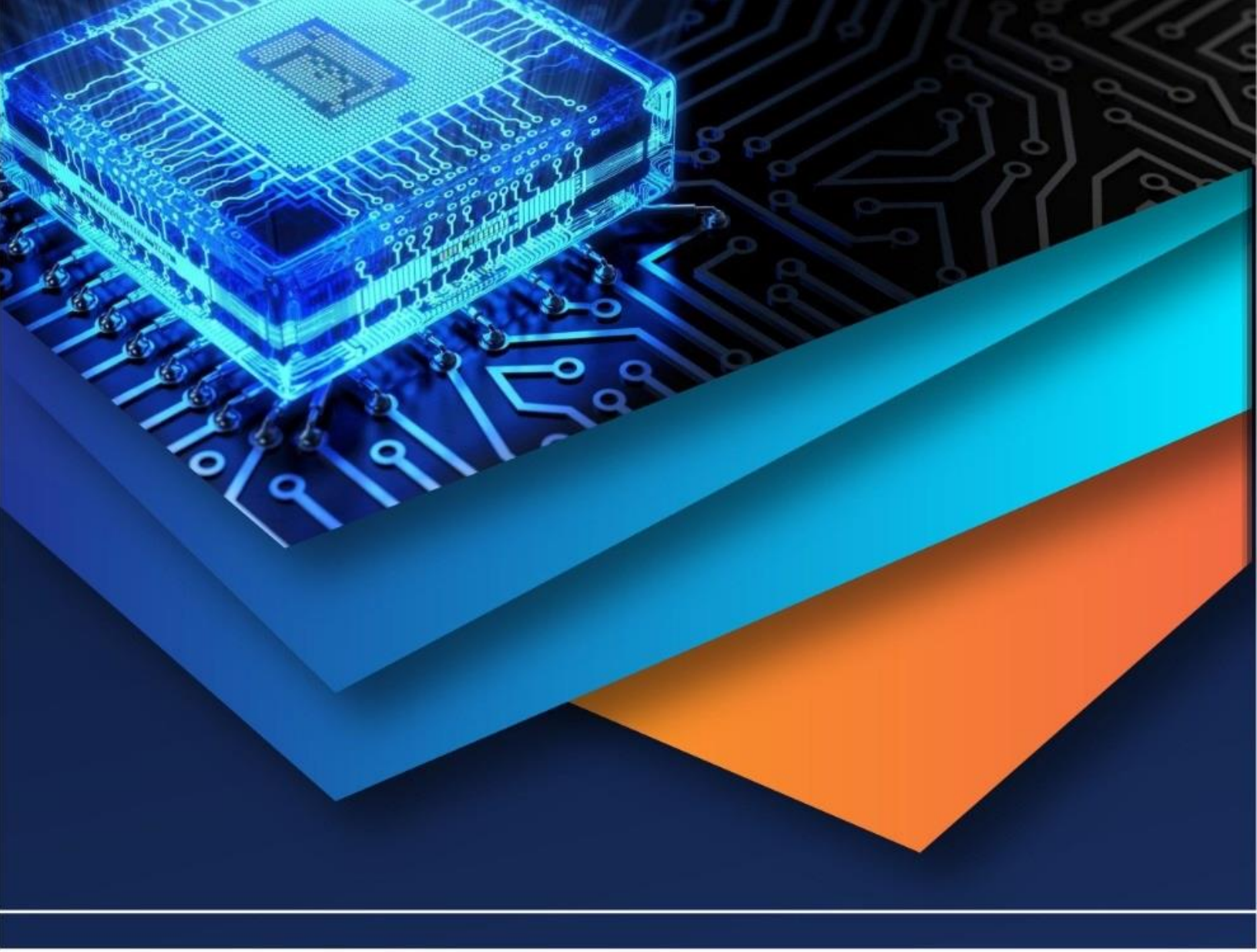

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