

Investigation of Experimental Fluorescent Tubes by Color Normal and Deficient Subjects

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(31.08.2011, Krisztián Samu PhD, BUTE)

Abstract

The aim of the current research was to compare four different experimental fluorescent tubes, used in different visual tasks with color normal and color deficient subjects. Perceived brightness, contrast sensitivity, visual acuity and subjective evaluation tested and recorded with color normal subjects. Ishihara plates and Farnsworth D-15 test were used with color deficient subjects.

1. Introduction

In the following years (based on the relevant EU directive) the ordinary (tungsten) light sources are going to increasingly removed from the usage. The EU's decision is conducting to the spread of the more economic (better luminous efficiency) light sources. Nowadays, the development and production of these economic light sources are advancing to the orientation of the compact and conventional fluorescent tubes. However, the fluorescent light sources are not able to replace them in every case. The current benefit of these lamps due to the prevalent and expense-efficient producing technology.

To achieve the several subjective and objective parameters of the tungsten bulbs (by the fluorescent tubes) measurements are necessary. The measurement of the objective parameters developed for traditional and fluorescent light sources. By instrumental measurements we can define the luminous efficiency, color reproduction, color temperature and other (photometric and radiometric) features.

There is much greater diversity in the area of the subjective measurements, because these tests try to measure the lighting from the aspects of the human perception. In the course of our research we developed new subjective investigating methods (and measured with them), which are typifying precisely the perceptual rating of the lights than the human measurement methods are

known from the literature. These human measurement methods helps to urgently consider the perceptual effects besides the instrumental measurements of the development of the fluorescent light sources. In this way helping the development of the tubes.

2. Light sources and subjects

Four light sources (T1, T2, T3, T4) with different spectral power distribution but the same correlated color temperature (CCT=3000K) used in similar illuminated areas and similar conditions to test visual effects in human tasks. Every fluorescent tube was used 100 hours before the beginning of the experiments.

After furnishing the laboratory, 15 color normal and 10 color deficient subjects were chosen for the experiment. The subjects were aged between 20 and 35. From the 10 color deficient subjects, there were 5 deutan, 3 protanop and 2 protan.

3. Methods

Prior to each test sequence an adaptation phase of 10 minutes has been introduced to the different lighting conditions. During this period the subjects were provided with landscape images along with observing surrounding colorful objects. This had an important meaning in measuring the subjective evaluation.

In this research we used complex visual tests from several literature and added innovations in.

3.1 Testing perceived brightness

The perceived brightness was measured using color normal subjects. Light booths used in other researches are usually closed thus do not give the opportunity to give judgment on

ambient lighting condition. In our research we built a booth half open for the ambient lighting and half closed for the reference lighting. The reference light was an incandescent 20W bulb with adjustable intensity. Similar patterns were placed in both the open and closed part of the booth and the reference light intensity was adjusted by the subject to set equal brightness. Each pattern was glued on a grey background providing the same background in the whole test. Altogether nine patterns were used with different shades of white, colors and surface textures. The location of the booth were set in each illuminated area so that the illumination on the pattern in the open booth half was the same. The reference light sources voltage and photometric parameters were checked and kept constant.

3.2 Contrast sensitivity test

In the contrast sensitivity (CS) tests we have used red-green (RG), blue-yellow (BY) and neutral (white-gray) gratings at 4 spatial frequencies (4, 10, 20, 40) and 26 contrast levels (1-100%). The test figures were observed from 5 m distance and the task was to tell the orientation (horizontal-vertical) of the gratings. This provided us with a threshold contrast at each spatial frequency where the contrast sensitivity still functions for the observer for the specific illuminant. To get valid results, the vertical and horizontal figures were distributed randomly. Only those values were registered where the subject was not able to determine anymore whether the grids are vertical or horizontal.

3.3 Visual acuity test

Visual acuity was measured on color normal subjects with the classical Kettesy plates, known from ophthalmological tests. The subjects had to read the decreasing letters on the plate from 5m distance. Each letter size corresponded to a specific visus value and the threshold was determined by the smallest letter size that she/he could read.

3.4 Subjective evaluation

The general subjective evaluation of the illumination was measured by numerical scaling method with different limiting terms within color normal subjects. The terms were the following: glaring-non-glaring, cold-warm, dark-

bright, artificial-natural, dull-inspiring, tiring-relaxing, pleasant-unpleasant. All the other opinions and comments of the subjects were also recorded.

3.5 Testing color vision

The color deficiency was measured with the color deficient subjects using Ishihara plates and Farnsworth D-15 test.

4. Results

4.1 Perceived brightness

The result of the perceived brightness test is shown in Fig. 1. Using T4 type lighting, 5 samples (1, 3, 4, 5, 9); with T1 lighting, samples 2 and 8; with T3 type fluorescent tubes, sample 6 and 7 were perceived brighter. According to the results, it can be pronounced that the most samples were perceived brighter when using the T4 fluorescent tubes.

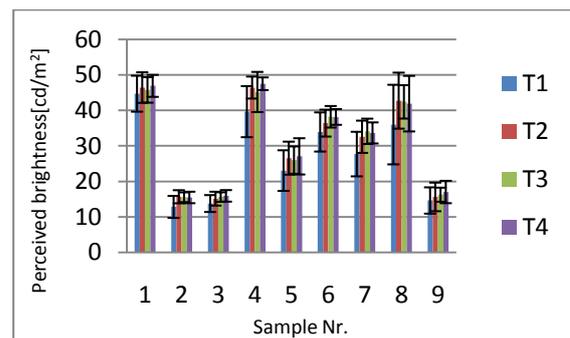


Fig. 1. Perceived brightness with different illuminations

4.2 Contrast sensitivity

With the red-green, the blue-yellow, and the black-white opponent color pairs the contrast sensitivity was the best when using the T4 lighting.

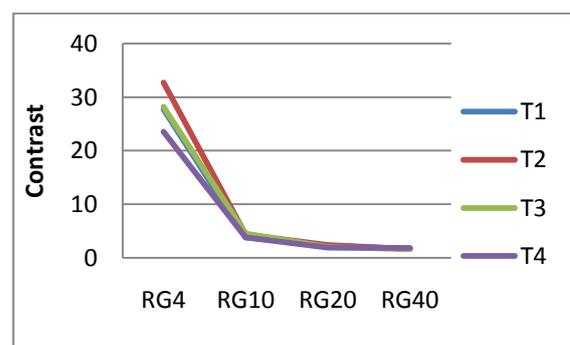


Fig. 2. Red-green contrast sensitivity

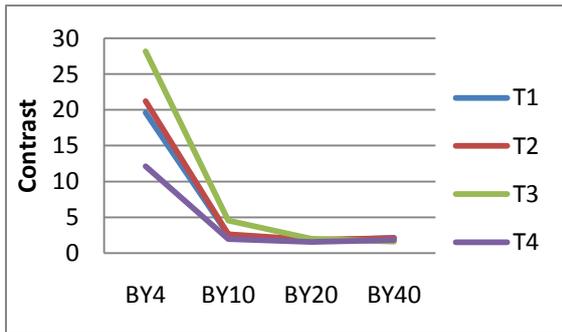


Fig. 3. Blue-yellow contrast sensitivity

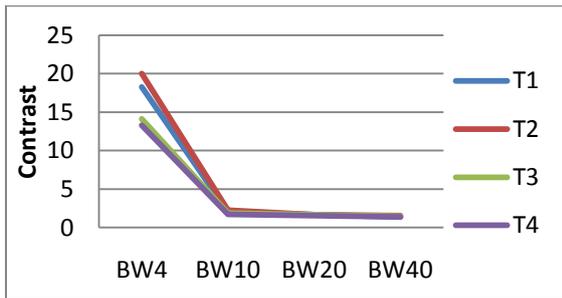


Fig. 4. Black-white contrast sensitivity

4.3 Visual acuity test

The visual acuity was mostly influenced by the T3 type lighting. The applied test did not find significant difference in the visual acuity between the effects of the four fluorescent tube types.

4.4 Subjective evaluation

Based on the results, it was found that the T2 illumination appears the brightest, the most artificial and more tiring than the light of the other fluorescent tubes. While the T1 lighting has the most non glaring effect, the light of the T3 type fluorescent tubes is the most relaxing, it has the most inspiring and the warmest effect.

4.5 Color vision tests

Color deficient subjects made mistakes when using Ishihara plates on different illuminations. The results show that subjects in general performed best with the T3 type fluorescent tubes.

The results of the Farnsworth D-15 test did not show significant difference between the 10 color deficient subjects, however some of them performed better with the light of the T3 light sources.

5. Conclusions and discussion

The results showed that the visual acuity of the subjects was mainly influenced by the T3 type illumination. With previous measures it was shown that a specially developed lighting box is capable of comparing how individuals perceive the brightness of the various illuminations. Although the subjects were subjectively evaluating the samples placed in the box, the different light sources could be objectively compared.

Based on the results, it was found that the subjects perceived more patterns (with different colors and surfaces) brighter when the T4 type fluorescent tube was illuminating.

The contrast sensitivity was the best when the T4 type fluorescent tubes were used.

The general subjective evaluation was measured by numerical scaling method, based on the evaluation formed during the measurements as well as on the previously mentioned landscape images.

According to the evaluation of the subjects, it can be said that the T2 illumination is much brighter, more tiring and the most artificial than the light of the other tubes. While the T1 illumination is the less glaring, the T3 type fluorescent tubes is the most pleasant, most inspiring, relaxing, and also stimulates a sense of warmth.

From the mistakes made with the Ishihara plates, it can be concluded that the T3 illumination is generally beneficial for the color deficient.

Although there were no significant differences found with the Farnsworth D-15 test, it can be concluded that the light of the T3 light sources is beneficial for the color deficient subjects.

In conclusion it can be said that the light of the T4 type fluorescent tubes were perceived as the brightest by the subjects. The same type was also beneficial for the contrast sensitivity.

The T3 type light source had a positive influence on the visual acuity. It can be also said that this light source had the best influence on the color vision of the color deficient subjects.

According to the subjective evaluation, the T2 fluorescent tube provides the most artificial and most tiring lighting.

This complex test could show the differences between light sources with almost similar conditions.

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