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SIMULATION METHOD FOR COLOR VISION ON DRIVERS BY INDUCING VISUAL STRESS

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Abstract: The characteristic of color perception is a functional process established at the level of the adapted cones to light, fact observed on night lighting when only rods are excited, and the eye is unable to distinguish colors. The purpose of this paper is to analyze the behavior of the human eye, in simulated laboratory conditions, by exposing them to different types of colored stimuli. Different types of wavelengths, time and frequency of exposure are taken into consideration, attempting to replicate thus the traffic conditions. For it will use a device self created specifically for these types of experimental simulations. It will track and analyze the reactions of subjects where the eye is protected and unprotected and various psychological conditions (most will track eye fatigue).
Keywords: Driver, Visual Function, Optometric Evaluation, Chromatic Vision, Simulation

INTRODUCTION

According to [1], chromatic sensation, along with the perception of light and shapes, are the three essential elements of vision. The eye perceives color stimuli in the visible spectrum, 375-760 nm range between infrared and ultraviolet, called the visible spectrum. Spectral colors are found only under experimental conditions surrounding world is basically formed from the mixture in varying amounts of several spectral colors.

Color perception is a function of the eye adapted to the light. When the light is weak, the human eye is unable to distinguish colors. In appropriate lighting conditions, color perception is achieved within a special region of the retina called the macula, where there are three types of visual pigments, corresponding to the three types of primary colors: red, green and blue. Color stimuli have certain physical characteristics: wavelength, intensity and purity light source. They correspond to certain sensory characteristics: hue, saturation and brightness.

Each cone is a carrier of one of photopigments and therefore reacts differently to colored light sources. For each of these three types there is a specific absorption curve peaks at different points of colors of the color spectrum (Figure 1) [2]:

- S cones: sensitive to light of short wavelength, with a peak at about 420 nm (blue);
- M cones: sensitive to light with an average wavelength having a peak at about 530 nm (green);
- L cones: sensitive to long wavelength light, with peak at about 560nm (red).

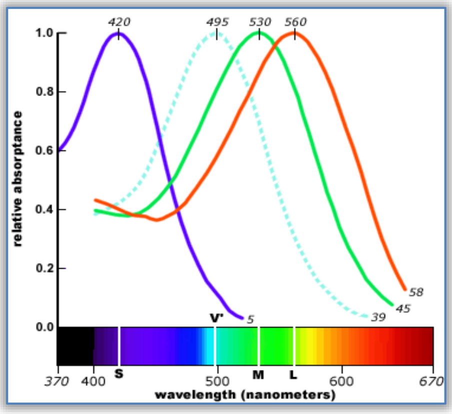

Figure 1: Cone Absorption Curves by Bruce MacEvoy

Color characteristics - brightness, tone and contrast - determined to eyeball a series of psycho-sensory phenomena that can constitute as methods for determining and verifying the color sensation. It has been found that the color sensation occurs only in photopic light, so cones are the photosensitive cells which participate in the formation of the sensations, so they are adapted to the three primary colors and can reproduce all colors in nature by mixing sensations. Experimental data and results of clinical and laboratory confirmed trichromatic theory that the cones are specialized for the three primary colors in their composition, without all three photo-pigments [2]. For a chromatically normal eye, the cones are specialized in a proportion of about 74% for red, approximately 10% for green, and for blue in a proportion of about 16%. Chromatic message transmission is performed according to Hering's theory of the so called theory of opposing pairs. This system is based on the fact that the first channel transmits gray levels, while the other two are opposed and never interferes; the red signal eliminates the green one by inhibiting the complementary color [3].

In 1931, an international group of experts known as the "Commission Internationale d'Eclairage" (CIE) [1] developed a mathematical model of colors, which represent observable space full of colors and values assigned to each set of three numbers (Figure 2).

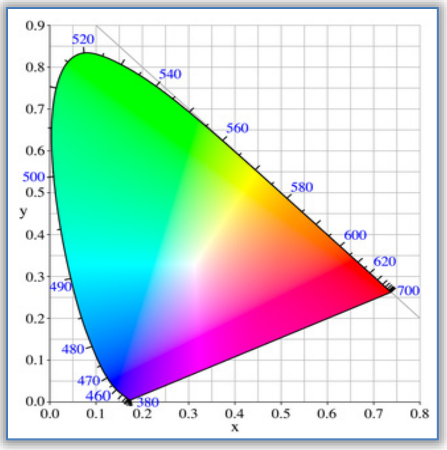

Figure 2: Chromaticity diagram of the visible spectrum provided by CIE in 1931 [1]

Contrast effects occur simultaneously for both blacks and whites stimuli and for chromatic stimuli [3]. For example, a uniform gray background appears brighter if crossed by white lines and darker when it is crossed by black lines; blue appears more intense on a yellow background, and yellow more intense on blue, unless were placed in the vicinity of other colors. After a short and intense stimulation, a series of oscillating processes appears. These are consecutive images or post-images and are highlighting where there is complete darkness. Post images are considered as some chain mechanisms, with the opposite reactions according to wavelength.

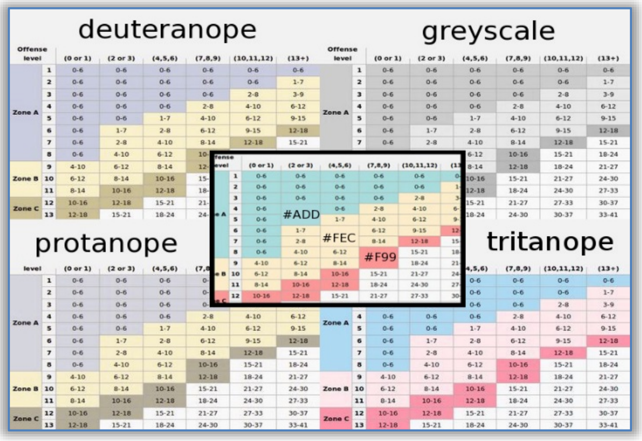

Figure 3: Testing the colors of a web chart [4]

Subjects with disorders chromatic usually have a uniton areas and even bands of gray tones instead that have not perceived (Figure 3) [4]:

a. Trichromacy in which all three cone pigments are present and color vision is normal.
b. Abnormal color sensation called dichromacy, are represented by visual disturbances of the colors by an inability of subjects to observe a certain wavelength of light radiation. Dichromatism occurs in a subject possessing two receptor systems and is blind to one of primary colors.
   ≡ Protanopes is contained in a proportion of 10% among the congenital disorders and consists in shortening of the color spectrum in its upper part, i.e. towards the red.
   ≡ Deuteranopes or Nagel's fault is 14% of congenital chromatic disorders and subjects did not perceive than partial color tone in the area of radiation with small wavelength.
   ≡ Tritanopes represents about 1% of congenital disorders that occur through lack of color receptor blue.
c. Monochromatic means only one cone pigment is functional. Can be easily associated with reduced visual acuity (usually 6/60), photophobia, nystagmus and sluggish pupil reflex to light.
d. Acromatopsy is a chromatic anomaly by which the cones are broken, either completely or partially, for which subjects perceive the world around only in gray levels.

Additionally, acquired dichromatism have the following characteristics: do not occur in isolation, but are closely related to damage other functions as decreased visual acuity or adaptation disorders; can be unilateral or limited to one side of the visual field; evolving with the condition that it imposes.

THE CONNECTION BETWEEN CHROMATIC VISION AND DARK ADAPTATION

The first step in achieving visual function happens in the retina and is converting light energy into luminous excitation. In carrying out this function takes part optical analyzer, including the cerebral cortex, thanks to which the sensations that arise in the occipital lobe photos do not remain isolated, meaningless, but are integrated into the whole process knowledge. The eyeball has the ability to modify the sensitivity of receptors depending on light intensity. Adaptation to low light is achieved through three mechanisms: changes in pupil diameter, increased sensitivity of the retina, optic neural adaptation path. The phenomenon of adaptation to darkness began to be studied since the 1860s because it reveals special functional movement coordination with major impact on the human factor [5].The study of retinal receptors adapt to darkness shows that from the beginning adapts cones, they synthesize photo-pigment faster and increase their sensitivity in the first 5-6 minutes, then follows the adjustment rods which is achieved more slowly due to the phenomenon of convergence and last all due to the higher number of rods in comparison to that of the cones [6]. This sensitivity is measured as the other sensations of the eye, by means of thresholds. Thus, one can determine the absolute light threshold, which represents the smallest amount of light that can be seen in the dark [7].

In photochemical interpreting of the scotopic vision, i.e. adapting to darkness, it is a matter of identifying chromophore substances of retinal structure. Rhodopsin is the pigment rods, which are found in far greater numbers than cones, so it is understandable why rhodopsin staining gives retina's color. Also in adapting to darkness intervened nervous factors too, pupil dilation and contraction of the retina are modulating the illumination, and inhibition processes in the retina occur.

If after a complete adaptation to darkness, the subject is exposed to light more or less intense, adapting to disappear by un-adopting, this is the reverse phenomenon of adaptation. During adapt to light phenomena occurring in the reverse occurring adaptation to darkness are [8]:

≡ It produces a decrease in retinal sensitivity;
≡ Visual purple discoloration;
≡ Changing the acid alkaline reaction on retina and even structural changes;
≡ Miosis occurs 0.2 - 0.5 seconds from the start of the trial and achieve maximum value in a few minutes.

For approximately the first 10 minutes in the dark, the cones require less light to reach a threshold response than do the rods. Thereafter, the rods require less light. The point at which the rods become more sensitive is called the rod-cone break (Figure 4).

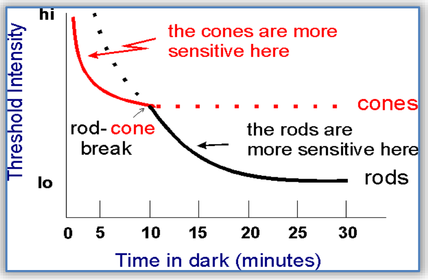

Figure 4: Dark adaptation function [8]

The eye adapts more quickly to light than in the dark. In the first 20 to 30 seconds there is an extreme decrease of the sensitivity, which is then followed by a slower decrease over a period of about 10 minutes [9]. Fogging is an extreme event in adapting to light. This is a transient visual embarrassment and painful, of course accompanied by a decrease in visual function, and is caused by an excess of light radiation in relation to the stage adaptation of the eyeball. Visual discomfort manifests more intense as the light source was stronger, brighter, and closer to the visual axis. The level of fogging varies according to subject status (fatigue, intoxication, alcohol or tanned condition), the diameter of the pupil (drug mydriasis can determines the state of fogging) [9]. Of colors, yellow is the least fogging, yellow light without radiation with short wavelengths (green and blue) causes a reduction in visual embarrassment and a net increase visibility by 10%. successive fogging are manifested as phenomena that occur after the suppression of fogging source and rehabilitation of eye sight before the moment of fogging, thus a short period of blindness occurs, then a gradual recovery of visual functions corresponding photo-pigments regeneration time. In these cases, visual acuity drops below 1/10 and sometimes lowers values [9].

CHROMATIC VISION FOR DRIVERS

Confusion colors (dichromatopsy) have repercussions decisive especially in shipping and rail traffic. Regarding the problem of color vision in the road, views are controversial. Not too call into question their ability to drive assessment in people with dichromatopsy whose visual acuity is reduced for any reason. The receptors sensitive to red or green are missing from the retina of people with dichromatopsy [10]. The auto driving, lack receptors sensitive to red presents special problems. The role of color vision on the road is controversial in different ways. According to some opinions, it has not been registered yet, worldwide, no very serious car accident whose cause has been driver's dichromatopsy. Without much notice, they refer to protanope, people who are insensitive to red and see a darker red rear lights. There is no data that could reveal that people with dichromatopsy would go more often at intersections when the traffic light is red than those without such problems. On the contrary, they are more cautious, aware of this deficiency [1].

The same conclusion applies concerning accident statistics, people with dichromatopsy not been involved in more accidents than those with normal color vision. This can be explained by the fact that these people on the road can also use other sources of information. In this connection, it may be mentioned the issue of recognizing traffic lights. At traffic lights, red is located in the up position, the middle yellow and green below [11]. This standardized settlement, awareness of its position and brightness of traffic lights, are a real help for people with color confusion. Increasing the size of signaling lamps further intensifies the possibility of their recognition. Sometimes red is framed in a circle, green in a triangle, differentiation being made through form. In adverse weather conditions or when light bulbs brake at low levels, the person with confusion red due to the shortening of the spectrum, evaluates the brake lights of the car in front as a distance greater than the reality, thus approaching too much of it.

In order to recognize color signals [11], some methods have been tried, such as wearing colored glasses, painting a green stripe on top of the windscreen, which thereby the color red appears darker and the lighter green. In many countries, including Romania, perfect color vision is mandatory for professional drivers, while for amateur drivers are allowed and easy dichromatopsy. A person with color confusion must draw attention to this disease and the risks of accidents [12]. Studies conducted in this area, indicate that the person with di-chromatopsy, through compliance with conditions, can become a driver as good as a person with normal color vision. The main condition is not to minimize in any event the suffering anomaly of vision like a principle which must guide them driving mode. The conditions of professional drivers are more severe in terms of possibilities for their views. In the case of amateur drivers can make some concessions, primarily in terms of visual acuity (if is corrected), and the color vision.

As foreseen in Romania, binocular visual acuity of professional drivers must be 100% and color vision must be perfect, determined using pseudo-izochromatics charts (Figure 5, [11]). At amateur drivers, monocular visual acuity should be good in one eye and the other more than 33%. Monophthalms are admitted only after a year of rehabilitation. A low degree of confusion color is admitted to this category [13].

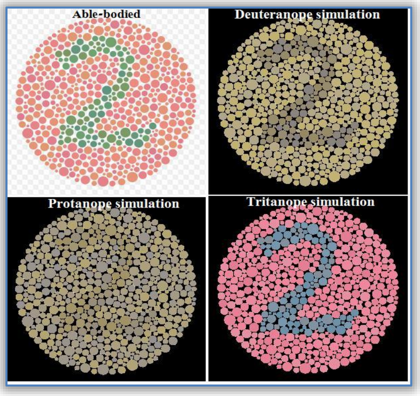

Figure 5: Pseudoizochromatics charts used for drivers

At night, due to lighting roads and intensity of light headlight own automobile, light sensitivity of the cones and rods are almost still pretty good, but the perception of shapes and contrasts decreases taking place and weakening capacity color recognition. Public lighting for economic reasons cannot be intensified. Own car headlights light intensity may be increased, which would be advantageous for the driver, in turn, would create difficulties for drivers coming from the opposite direction. But improved headlight technology solutions could lead to the improvement of sight overnight. Public lighting helps to increase the sense of comfort of the driver, decrease of fatigue and risk of injury. Clear view of the forms is characteristic of a good public enlightenment; this means that on a light background, pedestrians appear dark.

Regarding reflection roads [14], light color concrete is much more favorable than dark asphalt. From the viewpoint of adhesion and in optically terms, rough surface is more favorable. Newer for illuminating road are used aluminum granules that, especially from an oblique viewing angle, make the road looks brighter. In the evening, while driving, is not indicated wearing glasses whose light absorption exceeds 15%. So-called phototrophic glasses, which it gets darkener under the influence of light, are good during the day; are protectors to light because they become total darker only under the influence of ultraviolet rays, thus react slowly to changes in light. In this regard, protective glasses light is a good solution; they are darkens gradually from top to bottom, and make it possible to bring in a few seconds in front of bright area preferred by tilting the head back. The glasses with the polarization effect were found to be promising in the daytime but not at night, because it prevents the development of visual forms. Protective glasses should be in optically in perfect working order, without opacities and scratches. In the case of refractive eye problems, it is necessary to prescribe corrective colored lenses, optically proficient. In the case of refractive eye problems, it is necessary to prescribe corrective colored lenses, optically efficient.

Most upsetting moment, and at the same time generating dangerous driving situations at night, is the meeting with the headlights of oncoming vehicles. Sudden change in lighting intensity, for example, the reflector of oncoming vehicle, determines changes in the accommodative capability. Into movement of pedestrians or cyclists, it does not constitute a disturbing factor, so as the unwanted effect of the light source can be avoided by simply turning the head or line of vision, or even by stopping the move. Because of high speed, in the case of the vehicle, driver's sight is impossible to return long on or off; possibly speed can be reduced. With the change in the duration and level of visual accommodation, for elderly people objects are becoming invisible on the road, which might not have happened some time ago. Also high myopia may contribute to decreased ability to adapt to darkness. The most difficult moment to visual accommodate in the dark is the twilight, when the streets are still not illuminated: shadows are small, the colors are softened, thus it becomes difficult to recognize the pedestrian or cyclist. The driver, coming from a brightly illuminated room, accommodates hard outer darkness; therefore, it is better to wait a while before starting the vehicle until the eye regains adequate capacity to accommodate. In the case of a high myopia, accommodation is not perfect. Switching from a well-illuminated road on a dark street to the country can have a disruptive action. Into driving a car at night it is recommended dashboard illumination, which provides, in some measure, and the lighting of the car's interior. Colored windshield lowers the quality of night vision; it is no proper for solving the disruptive effects of light coming from oncoming headlights [15].

SIMULATION TESTS FOR VISUAL STRESS ON DRIVING

Abilities of sensory visual, such as measuring spatial resolution, contrast sensitivity, and sensitivity to light across the visual field, are useful for understanding the visibility of objects and events during driving, but they alone are insufficient to understand the complexity of the visual task of driving. Driving visual demands are complicated. Control of a vehicle occurs in an environment cluttered visual and involves simultaneous use of central and peripheral vision and tasks of primary and secondary (both visual and non-visual) [14]. As the vehicle moves through the environment, the visual world is changing rapidly. The driver is often uncertain as to when and where the event will be a critical eye. These applications have the task prompted researchers to examine the relationship between driver safety and performance and attention skills. Moreover, driving while unfit conditions or with eye problems can lead to a form of visual stress [6,8].

Visual Stress term is sometimes used to show symptoms and signs of eyestrain when reading, which can be reduced when color is used as therapy. In other interpretations, Meares-Irlen syndrome and refers to scotopic sensitivity syndrome. It is not yet recognized in medical terms and there is no universal agreement on its behalf. Symptoms related to disorders of visual perception in children with reading difficulty were first described by Olive Meares, but were listed by Helen Irlen.

According to [15], some of the main symptoms that occur during reading are: glare from the page; headaches when reading; sore eyes when reading; movement/blurring of print. Some of the signs may be: rubbing eyes; excessive blinking; poor concentration; inefficient reading; difficulty in keeping place.

In the case of auto traffic, visual stress can have various causes daytime and night:

- during the day:

Blindness due to solar light intensities;
Decreased visual acuity by exposure to high light intensity for a longer period of time;
Eye fatigue;
Distinguishing heavy of the forms and colors;

- during the night:

Blindness due to car headlights for oncoming traffic or event that occurs suddenly light in the visual field;
Pronounced eye fatigue on unmarked roads;
Unable to view the colors and shapes;
Very poor focus visual and accommodation.

The most common symptoms in case of visual stress are accentuated visual fatigue, inability to focus distance, tearing and redness, eye pain, generalized loss of ability to see colors, halos.

Starting at all this, we decided to perform a few experimental tests to expose your eyes to different light radiation and observe their reaction to colored stimuli.

Table 1: Measurements during test

	Distance 2 m in dark		
	Time (red)	Time (green)	Time (blue)
Subject 1	67	48	85
Subject 2	88	45	204
Subject 3	224	116	190
Subject 4	234	91	72
Subject 5	94	69	46

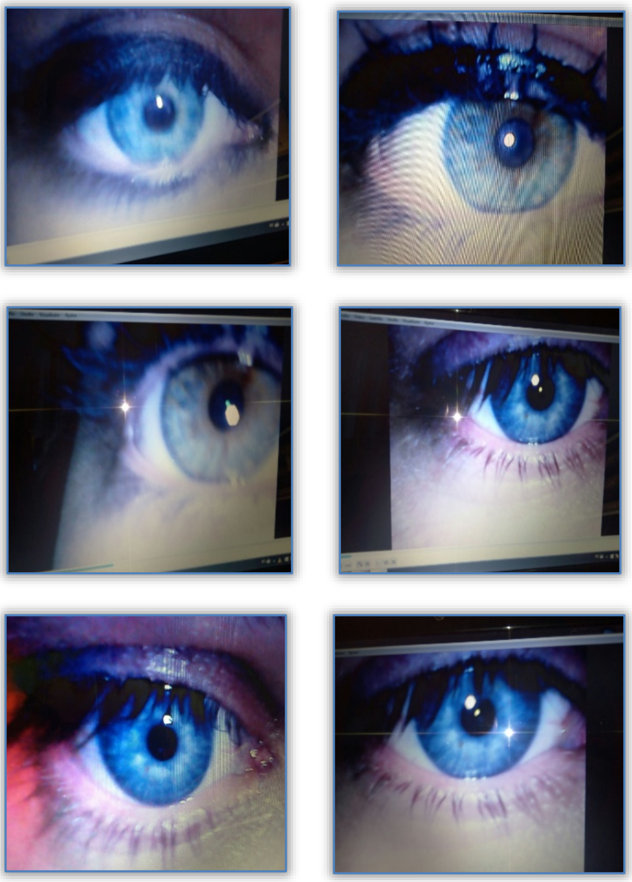

Figure 6: Experimental tests for simulating visual stress

We have used five subjects of similar age (20-23 years), 3 girls and 2 boys. One of the subject ware contact lens. They all pale iris (green or blue) so that they can view their better pupil. The subject was placed at a distance of 2 meters from the light source, in dark environment, and was successively exposed to stimuli red, green and blue. It measured the time and appeared blindness. Eye reaction to these stimuli was registered using a video camera that recorded the reaction of the pupil (Figure 6).

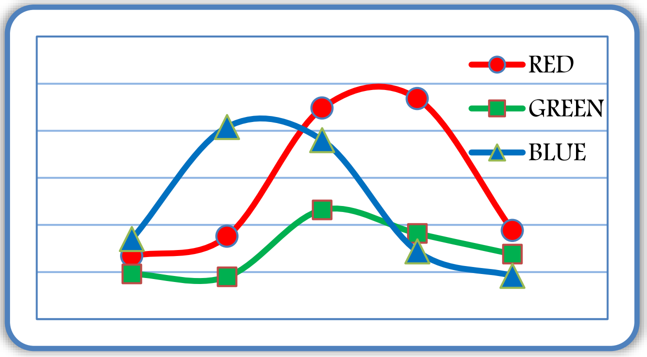

Figure 7: Results of the experimental test

Tests confirmed the theory set forth above. Subjects who had a higher sensitivity to a stimulus have resisted less. Sensations they were charged were great eye fatigue, dyplopia and decreased visual acuity. Eyes became congested and it took time to continue testing. In addition, there were other symptoms of general malaise headache or loss of balance. The method is subjective and based on perceptions and reactions of people tested. The experiment must continued by analyzing video filming. Pupil diameter measurement is essential in correlation with the psychological attitude of the subject.

CONCLUSION

For drivers color vision testing is important because it expresses their ability to properly view light signals and react on time to their appearance in traffic. Even in subjects who have no dichromatopsy, some eye problems can occur in certain situations resulting from special traffic conditions. For example, movement in poor lighting conditions or bright occurrence of events rapidly generated high intensity (light flash). Such situations can generate visual stress. Its symptoms are pressure in the eye; headache; some mild forms of the myopia; dyplopia (double images); changes in color perception; difficulty on focusing.

Note: This paper is based on the paper presented at The 1st International Conference "Experimental Mechanics in Engineering" - EMECH 2016, organized by Romanian Academy of Technical Sciences, Transilvania University of Brasov and Romanian Society of Theoretical and Applied Mechanics, in Brasov, ROMANIA, between 8 - 9 June 2016

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