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VISUAL FIELD EVALUATION METHOD OF THE AUTOMOBILE DRIVERS IN TRAFFIC

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ABSTRACT: Visual field is one of the main components of visual function that is required for drivers. Its undetected deficiencies can lead to problems in traffic because the driver is not able to observe all road events around him. One correct visual field requires a vision with sufficient visual acuity in all areas (central and peripheral). This paper aims to present the importance of visual field testing for drivers, especially for those professionals who will spend many hours in traffic. For this, it is presented an experiment that will highlight the difference between driving behavior with complete visual field, compared with one in which there is a narrowing of it.
Keywords: Driver, Visual Function, Optometric Evaluation, Visual Field, Simulation

1. INTRODUCTION

According to [1], in the complex man - traffic - vehicle, driver receives the most important information by sight, which explains why visual function is of paramount importance in driving the vehicle. In favorable conditions of view, this information is sufficient for safe driving. When driving the car overnight, the situation is different because the organ of sight, the eye being requested and a maximum length of time, the information obtained, even in a proper psychological state, barely enough for a safe drive. Role of other sensorial components, like hearing, cannot be considered so important in the activity of driving as one of the visual apparatus; people with hearing loss do not produce more traffic accidents than other people with normal hearing [2].

During driving, the person behind the wheel is used simultaneously by all elements of visual function, these coordinated applying them in different situations occurred. In the majority of traffic accidents, not the vision of perception and recognition is deficient, but the decision making process [3]. The main difficulty, so for the person who is driving, speed is the succession of alternating sequences, pressing time in processing visual information, timeliness and efficiency in finding and implementing appropriate choice. Although visual acuity is essential for driving, testing vision in her ensemble it is an extremely complex task, making it difficult to provide evidence of rigorous scientific analysis required for safe driving. Therefore, the study of the visual field and peripheral vision binocular can provide significant additional details [4].

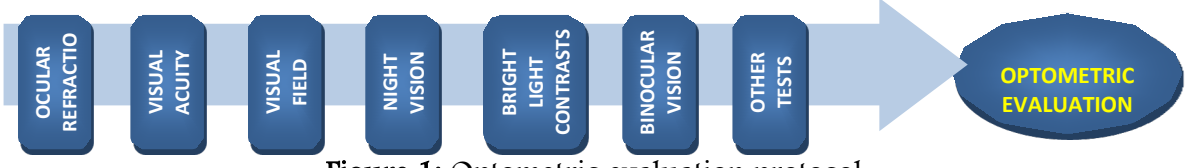


Figure 1: Optometric evaluation protocol

A person who does not have binocular vision is not aware of this, except for the situation where binocular vision loss occurred later, after time to strengthen them. In extreme situations, when environmental light intensity is very high or in the night, in traffic visual function parameters are required at maximum level for a long time, so that the car running is not safe [5]. Therefore, medical testing of drivers shall include, regularly, these mandatory tests: visual acuity; visual field; visual

ability in low light conditions; sensitivity to bright light and contrasts; diplopia (binocular vision anomalies); other eye conditions that endanger safe driving (Figure 1). Based on knowledge and analysis of visual function, in time, the researchers tried to develop a method of analysis of the visual field disorders to complement traditional diagnostic methods [6].

The purpose of this paper is to analyze all examination methods of visual field and binocular vision for drivers, so that, at the end, it could point out the most frequently used of them or how to complete this method to obtain a correct diagnosis in a shorter time. Based from the one of the examination methods, namely Esterman test, it tried completing the test for drivers.

2. VISUAL FIELD AND BINOCULAR VISION FOR DRIVERS

Usually for drivers, in optometric clinics, the performed ocular tests are following: visual acuity, color and night vision, binocular vision, peripheral and central vision, contrast sensitivity and visual field (Figure 2). Field of vision or peripheral vision corresponds to the portion of space that is projected on the retina of an eye sensitive property. It is therefore the spatial area in which objects are seen simultaneously by one-eye looks straight ahead of him. The geometrical representation of this space is that of a spherical surface the center of which is the optical center of the eye. Retinal sensitivity decreases from center to periphery, keeping it near "ora serrata" [7]. Distinguished monocular field of vision (one for each eye) and binocular field of vision, the space seen by both eyes simultaneously.

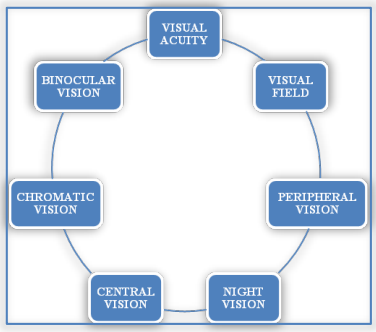


Figure 2: Tests performed in a optometric clinic necessary for evaluating drivers

The visual field is measured in degrees from the center (line of sight straight ahead) [8]. A normal healthy eye would be able to see about 95 degrees (to ear temporarily) and about 60 degrees nose. It should be also able to see 60 degrees above and 75 degrees below the front of the line of sight. This means that each eye monocular provides a horizontal field of 155 degrees and a vertical upright 135 degrees (Figure 3).

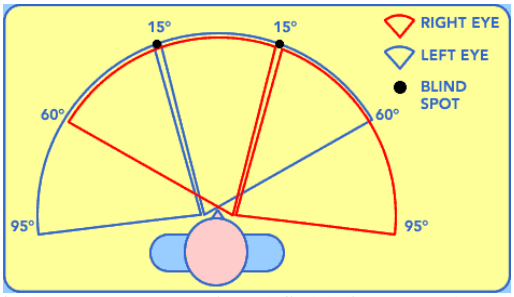


Figure 3: Human visual field (image adapted from www.testvision.org)

Binocular visual field is formed by the superposition of the two monocular fields in their nasal parts. In the middle of this common field of vision, the binocular field is created. Physiological limits of vision for light composite vary as follows: 80-90 degrees temporal and infero-temporal, 60-80 degrees down, 45-55 degrees up and 55-60 degrees nasal. The limits are due to peripheral projections neighboring formations. For colors, visual field limits are lower by about 10 degrees for blue, 20 degrees for red and 30 degrees for green.

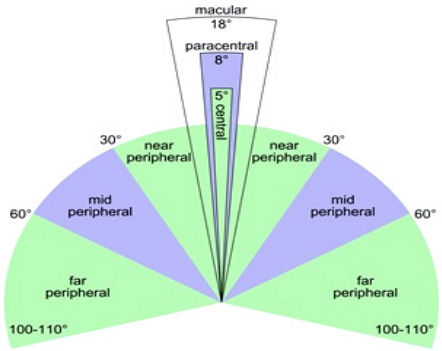


Figure 4: Peripheral vision of the human eye (image adapted from https://en.wikipedia.org)

In the analysis of visual sensation, they were examined phenomena only interested monocular vision. Although these phenomena occur in both eyes simultaneously, not charged yet because two images of the same object through a reflex of the merger, the two images are perceived as a unique sensation, which is binocular vision. Functionally, this phenomenon is achieved by the fact that both retains are superimposed on one another to coincide exactly maculae [9]. For there to be in good condition binocular vision requires certain conditions such as sensory or motor. Sensory conditions are assured of the integrity of the dioptric eye so anatomical images which form on the retina to be similar. Motor conditions require anatomical and functional integrity of oculomotor muscle and nerves.

Peripheral vision, one of the most important components for driver's vision, includes three levels (Figure 4) [8, 9]:

» Simultaneous perception that is, at the same time to the same or different two images received by each of the two eyes;

- Merging images, that means perception of one image data from the eyes;
- Stereoscopic view, which occurs by merging two slightly dissimilar images, because of the gap between the two images for each eye data, due to the existence inter-pupillary distance, so that the final image does not follow a perfect overlap between the two images.

3. DEVELOPMENT OF A METHOD FOR ANALYSIS OF DRIVER'S VISUAL FIELD

3.1. Establishment of the method

Seen from clinically practical point of view, visual field is essentially the area of space that a person can see at the same time. This relates to the field of view or how far into space a person is able to see without moving the eyes or head. In other words, if the light is reflected or emitted by an object reaches the retina surrounding space, then that object will be visible in the visual field [10]. According to the Driver and Vehicle Licensing Agency (DVLA) in the United Kingdom, The International Council of Ophthalmology has suggested the following driving field requirements: 120 degrees of horizontal field and 40 degrees of vertical field [2].

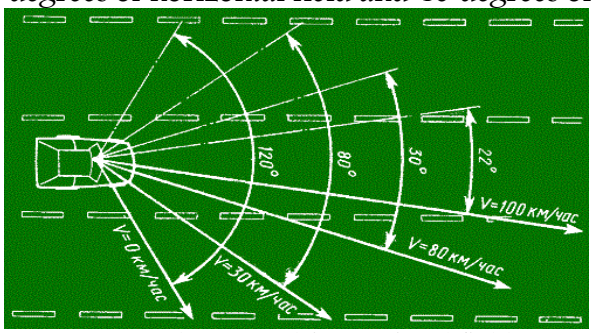


Figure 5: Dependence on driver's visual field on speed (image adapted from http://www.ccjdigital.com)

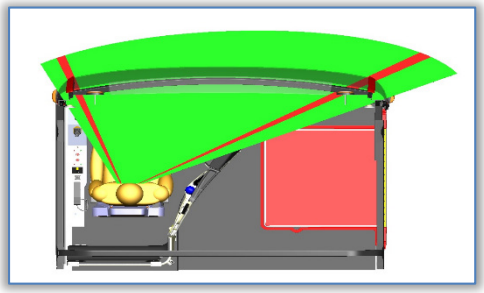


Figure 6: Driver's visual field (image adapted from http://customcoaches.com.au)

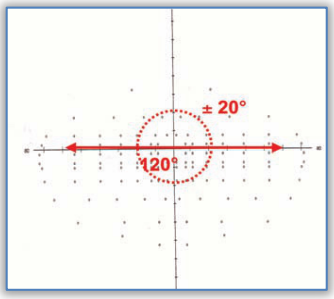


Figure 7: Normal Esterman binocular visual field test run on the Humphrey analyzer [12]

Normally, superior field of vision is obstructed 30-45 degree on mirror, although the exact location of location of these obstacles varies depending on the car model and the size and position of the driver at the wheel [11]. For a typical view during driving, the areas of particular functional importance are the central field of ± 20 degree to the horizontal region along the meridians. Normal field of vision is indispensable for professional drivers who spend a long time in traffic. In the meantime, medical tests for amateur drivers admit a slight narrowing it. Visual field is dependent on the speed (Figure 5): at 1 km/h, the normal visual field is 180 degree and decrease to 10 degree at 100 km/h. It is worth mentioning that running at high speed because of the intense attention the application, the ability of pathogenic agent's reception at the peripheral the visual field is reduced by inhibition of central, and, therefore, it may occurs differentiated visual field. For this reason, the driver, in terms of running at high speed, do not notice the object hit by car, but only heard a thud. Particular significance may have technical narrowing the visual field, car body elements also contribute to the narrowing of the visual field (Figure 6). In this paper will consider that on the driver's field of view is partially obstructed by the window and pillar between the windscreen and side window.

The evaluation system developed by Esterman is considered the basic standard for testing binocular field of view and is used by many authorities worldwide [12]. National requirements for field of vision to be able to drive significantly differ between countries. There is a Europe-wide minimum of 120 degrees horizontal opening, but Germany is the only country seeking central visual field examination [1]. Esterman test has the advantage of being relatively quick compared to other visual field tests (4-5 minutes to a normal subject), and is by far the most common test binocular field of ophthalmology and optometry clinics. Binocular visual field test of Esterman is most commonly run on analyzer Humphrey (Visual Field Analyzer) (Figure 7). It is a higher threshold test showing a single stimulus, very bright (10dB) at each of 120 locations in the visual field. The subject is asked to fix the center and to press a button when a stimulus is detected. The 120 points of the matrix stimuli are spread over a large area extending approximately ± 75 degrees horizontal, 35 degrees up and 55 degrees down.

According to the Esterman protocol, there are the following requirements [10]:

a. Visual field requirements for driving license are "a minimum horizontal field of view of 120

degrees and without material defects in 20 degrees from set point". This is a change of situation, compared to years ago, when are not allowed to miss a central point within ± 20 degrees.

b. Analyses of the missed random points. For this it is used a unique group of up to three neighboring points.

c. Significant loss of central vision occurs in the following situations:

» A group of four or more neighboring points that are wholly or partially in the central area of 20 degrees;

» Losses so one group consisting of three neighboring missed points up to and including 20 degrees from fixing and any additional items separately in the central area 20 degrees;

» Central losses of any size, which represents an extension of hemianopie or quadrantanopie.

Occasionally, an asymptomatic binocular visual field defect can be detected by an optometrist during a routine screening. Typically, in the clinic, visual field is tested thru perimeter. There are 2 main types of perimeters:

≡ Static perimeter is the most commonly performed method. The subject is asked to look at the center of an illuminated white screen with one eye, while the other eye is covered. Light spots of different brightness levels will flash on the white screen and the subject is asked to press a button every time see a light spot. It usually tests only the central 30 or 24 degrees and this takes approximately 4 to 7 minutes for each eye. Full field of vision tests can also be also performed thru static perimeter, but they will need more time and concentration for the subject. The method is objective as long as the subject may work well enough and fast, but the tests are made in static environment (which does not simulate driving conditions).

≡ Kinetic perimeter bright dots supposed to be moved inwards slowly, one by one, until they become visible. Instead, they are seen these bright points are marked on a piece of paper. Light point brightness and size can be changed. Test evolves from one point higher and brighter towards a smaller and less luminous intensity. The method is not automatic therefore, highly dependent on operator skill (optometrist), such as the results may be influenced by it. Kinetic perimeter is generally used for mapping visual field defects of neurological origin. It can often be used in case of optic neuritis or a stroke affecting visual pathways.

There is a subjective method, simple, easy to implement in any office. It does not require special tools and is easy to do, but requires direct collaboration of the subject. This can be done using either your fingers or small objects colored. It is necessary to ensure an optimal testing environment (especially light). Like any subjective method, provided accuracy is not very high and is useful only for detecting defects of field blanks, such as those that may occur in retinal detachment, ischemic optic neuropathy, and stroke. In addition, the method cannot achieve full visual fields where small defects.

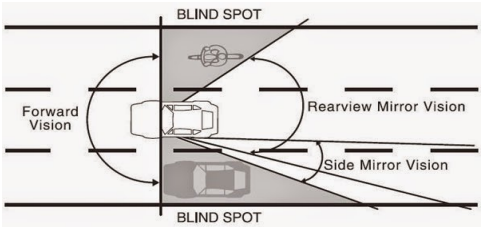


Figure 8: Driver's visual field in traffic (image adapted from http://macleangrosel.blogspot.ro/)

Based on the existing methods, a method has been proposed for analyzing driver's head posture behavior, which can change in traffic. If the position at the wheel of the driver is correct (adapted seat and mirrors), it will need to modify the position of the head and eyes so that he/she can see in a short time several areas required: looking ahead through the windshield to see traffic ahead, seeing in mirrors to observe rear traffic and near vision to see the equipment in the car like dashboard. (Figure 8) To do this, naturally, the driver must rotate their eyes, and if this is not enough, and the angle exceeds the limit of visual field, he/she must rotate the head in the direction necessary to accurate vision. If there is deficiencies visual field, especially in the case of a narrowed visual field, these moves will have a greater scale.

This method's aim is to simulate a narrowed visual field and analyze driver behavior in traffic in such a case. For this, we used a pair of protective glasses with very wide lenses. Was started with tests references, where the visual field is full, then to shrink it by covering the edges of the glasses. Was used two openings visual field, and the tests were done in real traffic different. It has ensured every time that the driver's position is the same (not modified seat and mirror positions) and is correct. Driver behavior has been viewed and recorded with a video camera auto, which allows shooting at night.

The components used are:

a. Protective glasses with colorless lens and adjustable arm length (4 positions) (Figure 9)

Figure 9: Used protective glasses

Figure 10: Video camera (image from the producer)

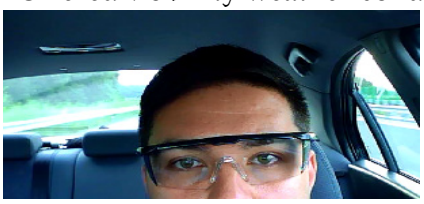
b. F198 Car Dash DVR with night vision (Figure 10). Video camera dashboard, windshield fixed straight in front of the driver to record the movements of the head and eyes. It is a video High Definition (HD) DVR camera with Motion Sensor and TFT LCD display 2.5". It can shoot at night, which provides the ability to perform tests in nocturnal driving conditions. It can capture images at a resolution (1280 x 480) which can then be played back on the LCD of 2.5". At the same time the camera can record and save video files automatically on the SD / MMC. The retaining device can be fixed very easily on the dashboard or even the windshield. Camera's characteristics are:

- Six infrared LEDs for increased visibility at night;
- Viewing angle 120 degrees;
- Resolutions of shooting 1280x960 / 720x480 / 640x480;
- Supports SD card up to 32GB;
- Show date and time on film;
- 1/4 color CMOS Image Sensor.

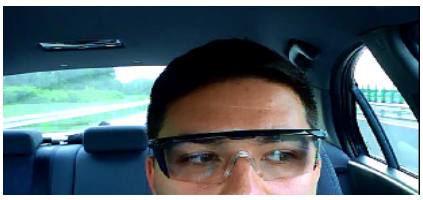
3.2. Results and discussions

Tests were performed and have identified the following factors:

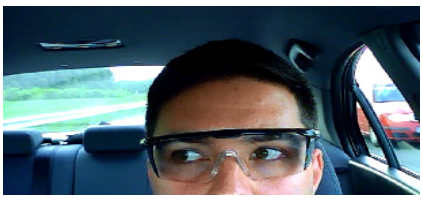
- Opening up the visual field (glasses provided);
- The type of traffic (in town or on the highway);
- Conduct of test time (diurnal or nocturnal);
- Eye fatigue (and not only) of the driver;
- Offered visibility weather conditions.



The reference test. Establishment of experimental conditions



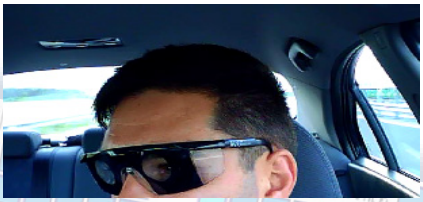
Eyes focused on the left side mirror with normal visual field



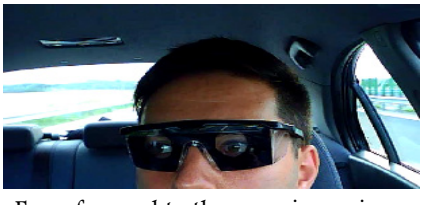
Eyes focused to the rearview mirror with normal visual field

Eyes focused on the right side mirror with normal visual field

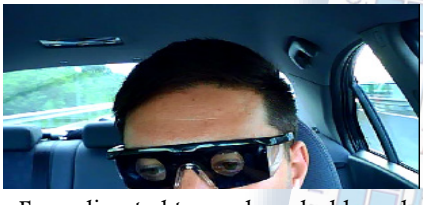
Eyes focused on the right side mirror ith a slight narrowing of the visual fielc



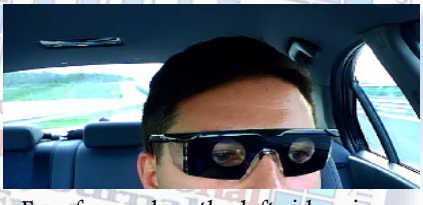
Eyes focused on the right side mirror with narrowed visual field



Eyes focused to the rearview mirror with narrowed visual field



Eyes directed toward on dashboard with narrowed visual field



Eyes focused on the left side mirror with narrowed visual field

Figure 11: Experimental tests for simulating in traffic the behavior of drivers with narrow visual field

In conducting the tests was taken into account keeping the same driver, same car, same seat and mirror positions (so as not to change the viewing angle), and the same equipment that operates under the same conditions. These tests were carried out with the direct involvement of Eng. Adrian Vidican, whom author thanks.

For reference, test conditions were set to be held experiment. They established the seat and mirror positions, were used without glasses narrowed visual field and the camera were calibrated (Figure 11). Tests revealed a narrowed visual field rotating head higher or lower depending on the opening offered by glasses. In this manner it wished to make a simulation of driving in the conditions of a narrowed visual field.

When driving on the highway, where the speed is high and there are multiple lanes displacement peripheral vision is less used than in the city, so even with a narrowing major field of vision, the ability to realize the position of the vehicle on the road is not affected, on the contrary, it helps to focus on walking straight ahead. In the city, however, decreased visual field creates a state of uncertainty, exacerbated by the need to continuously rotate head to view traffic environment completely. Although the legal maximum speed is lower in the city than on the highway, all events seem to be occurring faster than in reality unfolds. In the case of small deficiencies of the visual field, all those feelings can disappear with time and training required for drivers similar monocular that after a period of adjustment, can successfully deal with everyday driving task.

Fatigue is installed the faster the more reduced field of vision is more than either healthy normal vision. A positive aspect is that with decreased vision, the driver was forced to adopt the correct driving position to maximize the efficiency of the remaining field. Also, it demonstrated that weather conditions can substantially influence traffic behavior of such a driver, by additional reducing its visual acuity. Good behavior at bright light and contrasts are requested for driving at night.

4. CONCLUSION

While driving the car, the person behind the wheel is used simultaneously by all elements of visual function, these coordinated applying them in different situations arose. Normal field of vision is indispensable professional drivers and, for amateur drivers, it can admit a slight narrowing it. It has been found that running at high speed because of the intense attention the application, the ability of reception for pathogenic agents at the peripheral field of vision is reduced by inhibition of central and therefore differentiated visual field occurs. For this reason, the driver, in terms of running at high speed, cannot observe all traffic events. Technical narrowing of the visual field may also have particular significance. This may be unsuitable by wearing unsuitable glasses (with small frames and thick), or car body elements or objects affixed to the windscreen also contribute to the narrowing of the vision like barriers. Tests performed and presented in this paper have identified factors that may influence the leadership in maximum safety as traffic, time of day, type of road, driver fatigue, weather conditions, that highlight in particular the case of drivers who have deficiencies of the peripheral visual field.

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