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# EXPERIMENTAL RESEARCH REGARDING NIGHT VISIBILITY IN ROAD TRAFFIC

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***Abstract:*** *Driving on public roads is a complex activity, the pace and extent of its evolution, the behavior of drivers and environmental conditions may favor the road events. At night, the obstacles that are on or near the roadway seem to be further and bigger than the reality. Drivers should pay close attention and take extra caution especially when overtaking or on appreciation of the exact space required when crossing, especially in the terms of heterogeneous traffic - pedestrians, cars, bicycles.*
*All disturbing factors on driving ability are actually favorable elements of road accidents. The driver is the factor that influences largely the traffic conditions. In traffic at night, one of the problems is that the visibility of obstacles and road while driving on a road in alignment, in both cases, with or without traffic from the opposite direction. A special attention should be given to obstacles placed on the road and on the edge of it.*
***Keywords:*** *experiment, visibility, vehicle, pedestrian, traffic.*

## 1. INTRODUCTION

Human visual capacity is characterized by eye property to perceive differences in brightness, color and detail form, the sharpness and size of vision, the ability to accommodate and adapt of the eye. Possibility of the eye to distinguish the smallest detail of objects is called visual acuity. Under normal conditions, it takes to illuminate objects; illumination is more intense as the dimensions are smaller, the contrast is lower and succession rate is higher. Visual acuity is affected by factors such as: contrast, objects brightness, the illumination level and the relative motion between observer and object.
Visual capacity decreases when driving at night, which is due primarily to the low level of illumination. Pronounced decrease is due to the inability of the human eye to quickly adapt from light to dark conditions and to distinguish objects with a low contrast.
Retinal sensitivity in the process of adaptation to light changes gradually and slowly. Full adaptation of the eye to differences of illumination (dark adaptation) occurs in about 20 minutes; in the first 5 minutes, adaptation is obtained in a 60%. Appears therefore, the necessity of a fairly long period of adaptation, in situations where occur strong variations of illumination.
In this category falls glare manifested by retinal sensitivity annoying impaired at the sudden appearance of a powerful beam in the eye, this being adapted to darkness. The situation is common on the road at night, at the meeting of two vehicles that use high beam.
When the driver is exposed to high illumination, the pupil shrinks to adjust the beam. If the exposure is low, the pupil dilates to allow light to penetrate to the retina. The time needed to contract the pupil is about 0.3 seconds, while to dilate it takes 6 seconds. When the pupil is contracted, the driver cannot easily see items placed in the dark next to the illuminated area.
The term "blindness" is used to describe the presence of bright light or bright light reflections that interfere with the driver's view.
Sources of blindness include: headlights, street lighting, warning signs and lighting adjacent sites. Traffic engineers should make the effort to reduce sources of glare to an acceptable level.
Pedestrians are a risk factor for driving at night, especially in low light conditions and when wearing dark clothing.
Dangerous blindness is determined by the eye pupil diameter reduction from 8 mm to about 3 mm, which occurs in about 7 seconds. If the source of glare disappears after this time recovery period is at least 0.7 seconds and after recovery, the eye perceives objects contour difficulty even though they are intensely illuminated by

headlights. If the recovery period or immediately after is observed an obstacle, the driver reaction time is between 3 and 5 seconds due to extension of about 10 times of the perception and recognition phases.
Basically, the visibility of a surface depends on its size, its illumination level and the brightness of the environment in which it is found.

## 2. EXPERIMENTAL STUDY OF NIGHT VISIBILITY

Experimental study aimed to determine the characteristics of visibility and distance perception of obstacles by the driver in various driving conditions and visibility in the case of usage of low and high beam and meeting an oncoming vehicles column.
Choosing the location of experimental studies considered the following issues:
• tests performed on a section of road where there is no public lighting;
• no traffic on the road section during the test;
• road condition is good;
• road must be in alignment for a distance of at least 300m.

### 2.1. Materials and equipment used for tests

For measurements was used a Peugeot 206 and in order to simulate the oncoming traffic were used the following vehicles: Seat Cordoba, Renault Laguna I Break, Renault Laguna II, FORD Mondeo, VOLKSWAGEN Polo.

**Figure 1:** The vehicle used for tests

The luminance was determined using the lux meter GOSSEN Mavo Spot 2, for a range between $0.001 \div 100000 cd/m^2$.


**Figure 2:** The use of lux meter GOSSEN Mavo Spot 2

## 2.2. Testing scenario

In order to determine the visibility of a pedestrian on the roadway depending on the color of clothing following tests were performed:
A. Determination of the presence sensing distance of a pedestrian located in the middle of a lane by the driver of a car traveling at the high beam when oncoming vehicle is not running any.
For this we used a total of seven subjects as a pedestrian using six shirts with the following colors: white, yellow, red, green, blue, black and green reflective vest.
The measurements were conducted with a total of five subjects as a driver, posted in the vehicle that was moving from a distance of 250 meters until the driver could identify and recognize the nature of the obstacle. Speed of the vehicle was low, in order to establish more accurate the pedestrian identification point.
Distances were calculated using GPS coordinates. All measurements included two coordinates:
• a fixed coordinate of the point where pedestrians was located, dressed in different colors;
• a coordinate measured at the moment when the driver noticed and identified the presence of pedestrian.
At the same time was measured by using the lux meter, the light intensity perceived by the subject, reflected by the pedestrian color clothing at that distance.

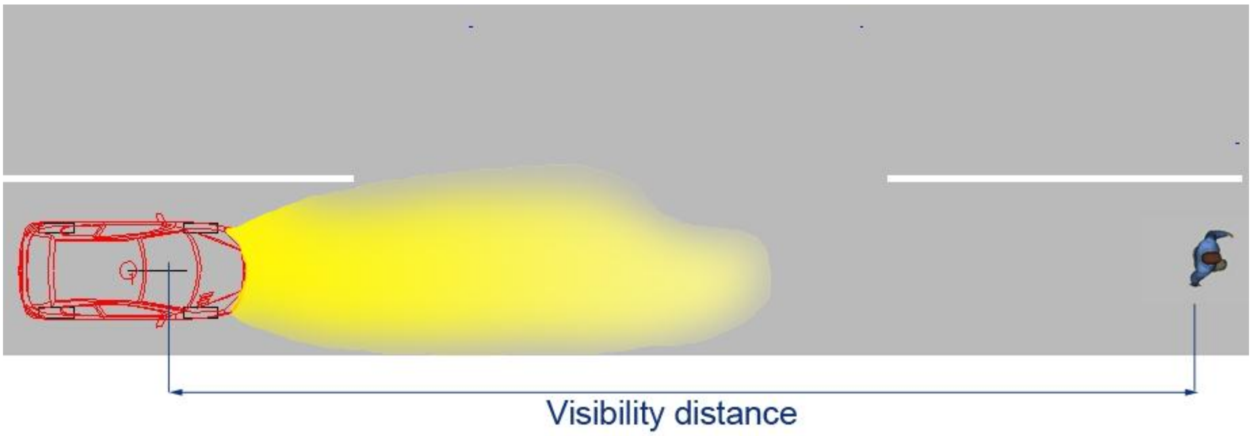


**Figure 3:** Scheme of experimental determination of the distance of visibility of a pedestrian when any oncoming vehicle is not running

**Table 1:** Identification of the pedestrian dressed in different colors

| No. | Name | Color | Distance [m] | Luminance [cd/m$^2$] |
|---|---|---|---|---|
| 1 | Subject1 | Yellow | 222 | 0.16 |
| | | White | 182 | 0.09 |
| | | Red | 174 | 0.16 |
| | | Reflective vest | 172 | 2.57 |
| | | Green | 156 | 0.15 |
| | | Blue | 130 | 0.12 |
| | | Black | 108 | 0.08 |
| | | | | |
| 2 | Subject2 | Yellow | 222 | 0.1 |
| | | White | 189 | 0.11 |
| | | Red | 190 | 0.09 |
| | | Reflective vest | 189 | 2.85 |
| | | Green | 155 | 0.07 |
| | | Blue | 141 | 0.08 |
| | | Black | 115 | 0.08 |
| | | | | |
| 3 | Subject3 | Yellow | 182 | 0.12 |
| | | White | 166 | 0.1 |
| | | Red | 143 | 0.1 |
| | | Reflective vest | 141 | 3.7 |

| | | | | |
|---|---|---|---|---|
| | | Green | 126 | 0.15 |
| | | Blue | 125 | 0.09 |
| | | Black | 98 | 0.08 |
| | | | | |
| 4 | Subject4 | Yellow | 193 | 0.09 |
| | | White | 192 | 0.11 |
| | | Red | 153 | 0.1 |
| | | Green | 152 | 0.09 |
| | | Reflective vest | 142 | 4.5 |
| | | Blue | 138 | 0.1 |
| | | Black | 115 | 0.11 |
| | | | | |
| 5 | Subject5 | Yellow | 192 | 0.08 |
| | | White | 168 | 0.1 |
| | | Green | 151 | 0.1 |
| | | Red | 148 | 0.08 |
| | | Reflective vest | 147 | 4.13 |
| | | Blue | 131 | 0.09 |
| | | Black | 110 | 0.1 |

The analysis of measurements indicates that luminance is higher in the case of green reflective vest; all subjects identified the pedestrian as an obstacle at a distance much smaller than the other colors of clothing. The explanation is that due to lack of pedestrian movement, light reflected from the reflective vest is interpreted by subjects as a road sign, such cases can happen in reality.

B. Determination of the presence sensing distance of a pedestrian located in the middle of a lane by the driver of a car traveling at the low beam when oncoming vehicles column is moving.

For this phase of the experiment was simulated a column of 5 vehicles traveling in the opposite direction with low beam on. Vehicles were placed at a distance of 20 meters from each other.

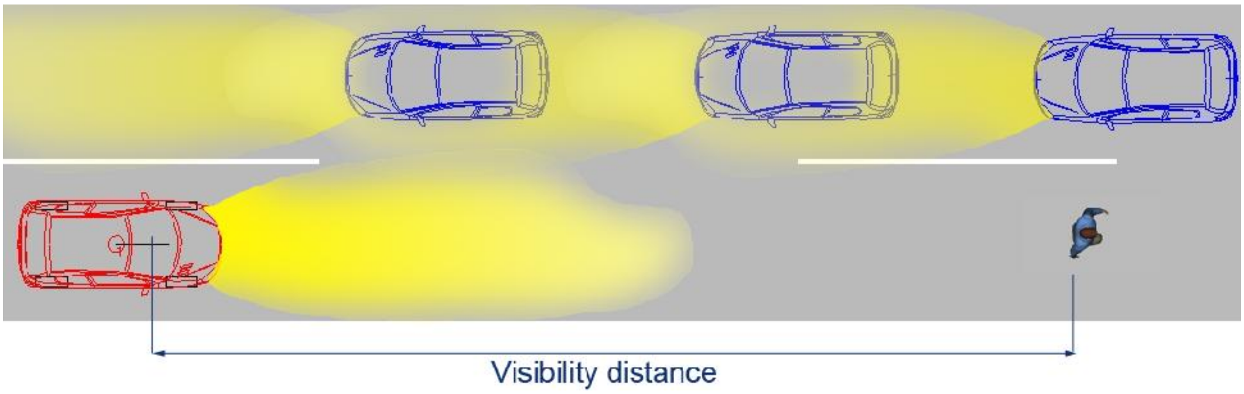


**Figure 4:** Scheme of experimental determination of the distance of visibility of a pedestrian when an oncoming vehicles column is running

Distances were calculated using GPS coordinates and pedestrians have only used yellow shirt and reflective green vest.

**Table 2:** Identification of the pedestrian dressed in yellow shirt and reflective green vest

| No. | Name | Distance [m] | | Luminance [cd/m$^2$] | |
|---|---|---|---|---|---|
| | | Yellow | Reflective green vest | Yellow | Reflective green vest |
| 1 | Subject1 | 83 | 124 | 2,6 | 4,7 |
| 2 | Subject2 | 83 | 118 | 3,11 | 4 |
| 3 | Subject3 | 79 | 93 | 2,3 | 5,2 |

| | | | | | |
|---|---|---|---|---|---|
| **4** | Subject4 | 63 | 89 | 1,96 | 3,4 |
| **5** | Subject5 | 61 | 87 | 2,7 | 5,8 |
| **6** | Subject6 | 59 | 85 | 2,33 | 3,1 |
| **7** | Subject7 | 67 | 73 | 3,2 | 4,51 |

## 3. CONCLUSION

The most common crashes types at night are: vehicle - pedestrian or vehicle - bicycle. The answer of the eyes is reduced when the driver is in the scotopic mode. The driver can avoid the impact with the pedestrian only if the driver observes sufficiently in advance the presence of pedestrian, impact imminence and triggers immediate and strong the braking maneuver.
The normal reaction time when is notified a pedestrian intrusion is 1.5 seconds, during which the car continues to move and it continues to run after the brake pedal has been pressed, during entering into operation of the braking system, as extra braking space is needed.
When the obstacle can be identified it triggers two types of danger state: state of potential danger and imminent danger condition.
Potentially hazardous condition is an early state of identification of an obstacle, in this case a pedestrian, that has a predictable motion, while on the imminent state of danger is due to an intrusion of pedestrians on the road that triggers actions and maneuvers that normally were not performed.
Distance of observation and identification of potential barrier depends on the contrast between the pedestrian and the environment, the traffic situation and physiological perception ability of the driver.
The degree of contrast is very important for pedestrian detection. Pedestrian is twice as visible if the contrast is positive. The driver easily perceive the pedestrian in positive contrast because is seen as an object that reflects more light than its surroundings, which is generally dark or dimly lit.
In this situation, in terms of pedestrian visualization it is important clothing. If it is light colored, it will reflect a greater amount of light to the driver.
Determinations were static and did not taken into account the speed of the vehicle in which the driver was as a receiver of visual stimulus, so it wasn't taken into account the time elapsed from the stimulus perceived until obstacle identification.
In other words, distances from which it was identified the obstacle (pedestrian) equipped with different colored clothes are much lower if it is considered the space traveled by the vehicle from the moment of receipt the light stimulus and until driver responding.
To determine the actual distance on which is perceived a pedestrian on the roadway, on the same lane with the receiving vehicle, the experimental tests should be conducted with vehicles moving with different speeds.
Another disadvantage of experimental measurements is that subjects' receptors (drivers) are trained to identify the roadway obstacle when in reality they are often surprised by its appearance.
Following data analysis revealed that the viewing distances decreases when column of oncoming vehicles are running. Another disadvantage of these static measurements is that the delayed adaptation of the human eye to stroboscopic effect could not be captured in the case of a successive passage light from a column of vehicles moving in the opposite direction.
The main advantage of these determinations is that it provides relevant data of maximum visibility distances under similar conditions as those in the experiments.
In dynamic real conditions when a driver encounters a pedestrian on the roadway, if added and oncoming traffic of vehicles circulating in the column, then the values of visibility distances decrease compared to those determined in static experiment.
In this case, the driver adaptation is more difficult to the changes of headlights light intensity of oncoming traffic and during the eye sensitivity recovery time cannot grasp and identify obstacles.
In dynamic movement could result the temporarily blinding of the driver because of the car lights moving in the opposite direction.

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