

Pedestrian visibility at night: the influence of the pedestrian clothing and the defective headlamp of the car

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Abstract. Low night vision is a factor contributing to the production of traffic accidents. In this work, we investigated the distance from which pedestrians can be seen by night, by a driver driving a car with a single functional headlamp. Six pedestrian clothing conditions were tested (black, blue, red, green, yellow and reflective vest). Pedestrians wearing dark clothing (black, blue) were only visible from a distance of 10 meters; the best visibility was for the pedestrian that wearing the reflective vest. The results demonstrate the importance of pedestrian clothing during night time on visibility while traveling on the public road.

1. Introduction

Road accident is an unpredictable event occurring on a public roadway where at least one moving vehicle and other traffic participants are involved, resulting in material damage, injury or death of the person. The cause of most accidents is the low visibility of car participants at night [1]. This is primarily due to the difficulty in reading the traffic information, the colour differences of other traffic cars, the ability to see the edges of the low road, and the effort to the human eye [2].

In the case of drivers, their reduced night-time visibility is due to several factors:

- Fatigue is a factor that influences visibility. This leads to a decrease in driving capacity. Typically, in the time range of 03:00 - 07:00 this tends to the maximum, as in the period when he normally sleeps [3].
- Alcohol is the next major contributor to road accidents. This, along with night driving, is the leading cause of death among young drivers [3,4].
- Age, being a major influence of night vision. The decrease in visual acuity begins at the age of 20 years. Over time, the amount of light that goes through the cornea decreases, so somewhere around the age of 60 it is needed 3 times more light than at the age of 20 to see the same details [5].

In addition to driving factors, there are external factors that influence their visibility, such as:

- Lighting with headlights, where the visible road sector is much lower than during the day. Darkness allows perceiving distances with great difficulty, so that headlights, especially poorly tuned, can create a blinding effect [6,7].
- Unlit or poorly illuminated roads, which affect the visibility of the drivers, becoming much lower and pedestrian sensing, will be much slower [7,8].
- Weather conditions (fog, rain, snow, etc.) are an unpredictable external factor and cause night vision [9].

Pedestrians are the most vulnerable traffickers due to lack of protection during a collision with a car. A proper visibility of the pedestrian can reduce the consequences of an accident. During night driving, there is the possibility that the objects placed in the vehicle paths are not detected in time [8,9].

The objective of the work is the influence of the colour of pedestrian clothes on the visibility in the night conditions, in the case of vehicles running with defects of the lighting system.

2. Method

To perform this experiment, the measurements were made on the test track, with a length of 50 m, without street lighting. On this test track marks were made at intervals of 10 meters, so the test track was divided into 5 intervals.



Figure 1. Test track.

Six pedestrians equipped with different colours clothes and a Dacia Logan were used to achieve the objectives. The pedestrian was located at a distance of 0.5 m from the right merge of the road, and the car was positioned at a distance of 10 to 50 m from the pedestrian. The tests were carried out using a single car headlight (simulating the failure of the other headlamp).

Pedestrians wore a black, blue, red, green, yellow blouses and black blouse with reflective vest.



Figure 2. Pedestrians clothes.

A Fujifilm X-T1 camera was used to capture photos from the car. This camera allowed capturing photos at night without changing the focus.

For image processing was used the PC-RECT 4.2 software, developed by DSD Austria, specializing in photogrammetry. This software determines the brightness on different areas of the image and can calculate the contrast between the two analysed areas, so the software gives the visibility of the pedestrian by comparing the two luminance values and the contrast determination. The program uses Adrian Werner's method, which is the method of stability of the visibility of the object under different light conditions.

The analysed area of the pedestrian was the chest area, the wearing area of the reflective vest. The program determines the value of the luminance of the object in the area of the pedestrian's chest (1) and compares it with the luminance of the environment (2), thus obtaining the contrast value.

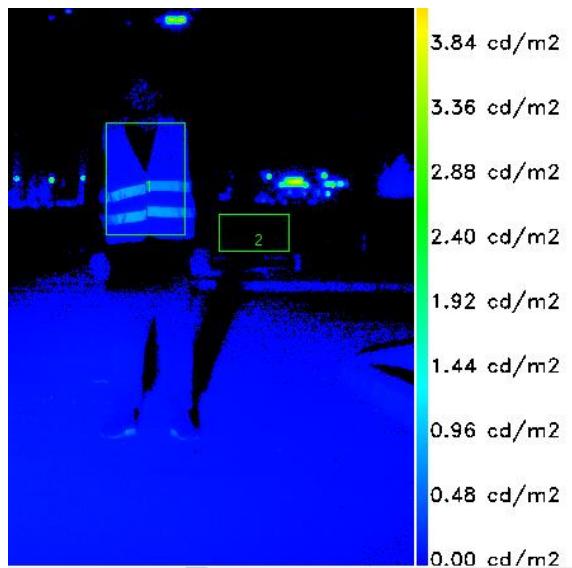


Figure 3. Photo processing to determine the visibility of the pedestrian.

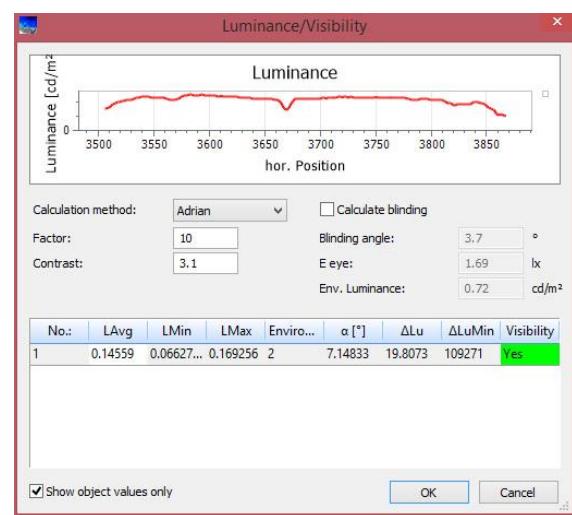


Figure 4. Luminance determination window from PC-RECT.

The software extracts all the data in a table showing the object's visibility based on the ΔLu parameter, which represents the difference between the two selected areas.

L_{avg} – average luminance; L_{Min} , L_{Max} – shows the minimum and maximum luminance of the respective area; α - object size; Environment – assigned background area; ΔLu – luminance difference, it is the difference between LAvg of the defined area and LAvg of the background area; ΔL – luminance difference threshold.

3. Results

The pedestrians wore a black (Bk), blue (B), red (R), green (G), yellow (Y) blouses and black blouse with reflective vest (BkRV).

In figure 5 are presented the results for the distance of 10 meters between the car and the pedestrian. The greatest contrast is for the pedestrian that wears the reflective vest, regardless of the functional headlamp.

The small contrast is found for the pedestrian that wears black clothing when the right headlamp works.

For the distance of 20 meters between the car and the pedestrian (figure 6), the biggest contrast is for the pedestrian that wear the reflective vest. At this distance, the pedestrians that wear black or blue clothing are not visible (they are confused with the environment). The pedestrians that wear green or red clothing are more visible when the left-hand headlight of the car works.

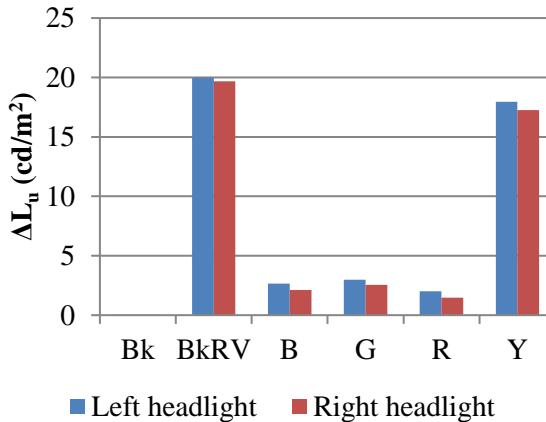


Figure 4. Contrast at 10 m distance.

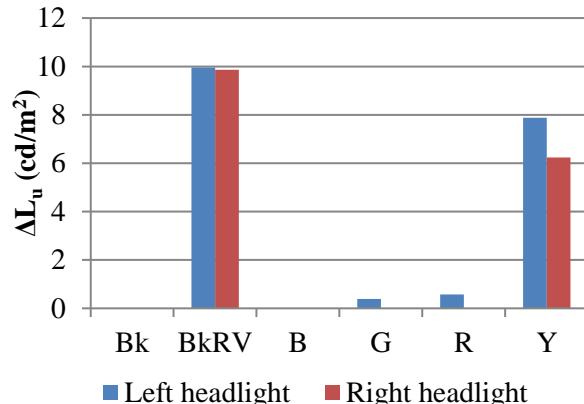


Figure 5. Contrast at 20 m distance.

At a distance of 30 meters between the car and the pedestrian (figure 7), the pedestrian that wears yellow clothing or a reflective vest are visible, regardless of the headlight that works.

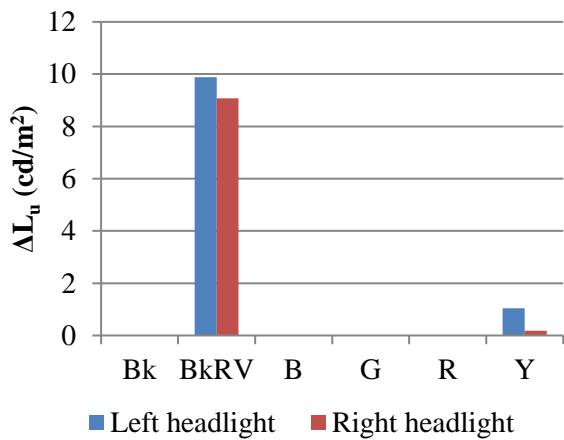


Figure 6. Contrast at 30 m distance.

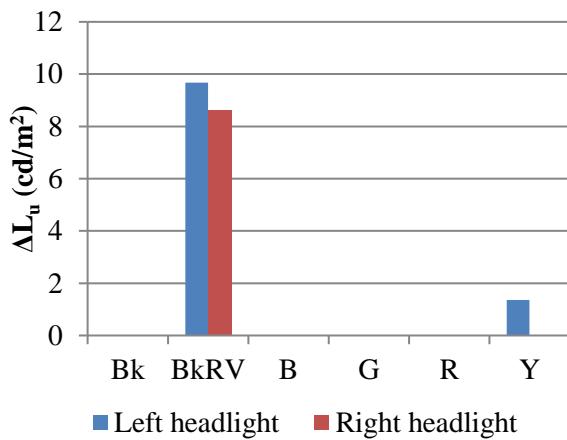


Figure 7. Contrast at 40 m distance.

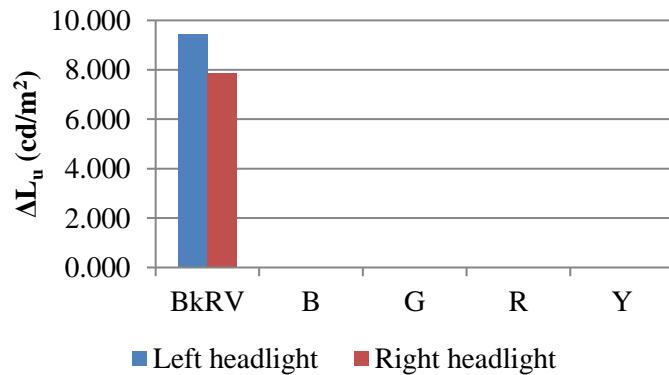


Figure 8. Contrast at 50 m distance.

At a distance of 40 meters (figure 8), pedestrian with yellow clothing are not visible if the car has the left headlamp defective. At a distance of 50 meters (figure 9), only pedestrians with a reflective vest are visible.

4. Conclusions

The present experiment sought to determine the visibility of pedestrians depending on their worn clothing, in the event of damage to the vehicle lighting system (a defective light bulb). The data demonstrate that pedestrian clothing and functional headlamp significantly affect both the probability that a driver will recognize the presence of a pedestrian on the road and the distance to which pedestrians are recognized in the night.

Pedestrian clothing had a powerful effect on pedestrian visibility. When the pedestrian wore the black coat he was hardly sizable of it at a distance of 10 m. For the other distances tested, the pedestrian in black was confused with the background (it was invisible). The moment of visibility of the pedestrian wearing black clothes occurs at a point that may not allow drivers from stopping in time to avoid a collision.

The visibility of pedestrians is improved by wearing light-coloured clothes (greater contrast with the environment). In the case of green or red blouses, the pedestrians could be seen from a distance of 20 m. Pedestrians who wear yellow blouses can be seen from a distance of 40 m. Pedestrians who wear a reflective vest can be seen from a distance of 50 m.

The functional headlamp had a significant effect on pedestrians' recognition. In the case of the operation of the left-hand headlamp, pedestrians are more easily recognized.

5. References

- [1] Rumar K 1990 The basic driver error: late detection. *Ergonomics*, 32, **1281-90**
- [2] Sullivan J M and Flannagan M J 2002 The role of ambient light level in fatal crashes: inferences from daylight saving time transitions. *Accident Analysis and Prevention*, 34, **487-498**
- [3] Summala H and Mikkola T 1994 Fatal accidents among car and truck drivers: effects of fatigue, age, and alcohol consumption. *Hum. Factors* 36 (2), **315–326**
- [4] Owens D A and Sivak M 1996 Differentiation of visibility and alcohol as contributors to twilight road fatalities. *Human Factors*, 38, **680-689**
- [5] Chrysler S T, Danielson S M and Kirby VM 1996 Age differences in visual abilities in nighttime driving field conditions. *Proc Human Factors Ergonomics Soc 40th Meeting*, **923-927**
- [6] Tolea B, Antoonya C and Beles H 2015 Assessment of the injury severity of the pedestrian lower limbs at the collision with a vehicle. *Proc of the Annual Session of Scientific papers “IMT-Oradea 2015” XIV*, **189-192**
- [7] Brooks J O, Tyrell R A and Olson H M 2001 Pedestrian visibility at night: evaluating a method of teaching young drivers to be safer pedestrians. *80th Annual Meeting of the Transportation Research Board, Washington*
- [8] Gegenfurtner K R, Mayser H and Sharpe L T 1999 Seeing movement in the dark. *Nature* 398, **475-476**
- [9] Mannerling F L and Bhat C R 2014 Analytic methods in accident research: methodological frontier and future directions. *Anal. Methods Accid. Res.* 1, **1-227**