Night-Time Experiments on Driving RHD Vehicles in LHD Traffic Conditions and Pedestrian Crossing Safety

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Abstract. Vehicle lighting systems are critical to the safety of night road traffic. Depending on the level of road lighting (urban or extra-urban), the lighting system settings and the nature of the light source used, the position of the steering wheel (LHD - left hand driving or RHD - right hand driving) the visibility and perceptions of the driver may be influenced. In this paper we aim to experimentally analyze the influences of the elements mentioned above on the visibility, perception and possibilities of avoiding a potential accident with a pedestrian crossing the unlit road at night. The analysis included the use of several cars and systems. Multiple for the detection and recording of perceptions and visibility. Various configurations were also used for the pedestrian crossing, but also for the driver of the vehicle, assuming an increase or decrease in visibility on the pedestrian in low beam headlamps. These experiments provide up-to-date information on the possibilities of avoiding road accidents in night-time traffic conditions. The results obtained can also be useful for more accurate calibration of the emergency braking of driver assistance systems.

Keywords: Night-time road traffic · LHD vehicles · RHD vehicles · Pedestrian safety · Accident avoidance

1 Introduction

Road accidents resulting in fatalities remain a major problem for Romania, in the context of the European Union. Thus, according to Fig. 1 [1], Romania registers the highest number of fatalities compared to 1 million population. There are many causes of this unwanted situation, starting from the inadequate condition of the road network and continuing with the age of the car fleet, the weakness of the road education and the technical non-conformities of many vehicles registered in Romania.

Even in pandemic conditions, where reduced economic activity has meant a reduction in road traffic intensity, the number of road accidents has continued to rise. An indirect cause was probably the reduction in the density of vehicles on the road network, which stimulated driving at higher speeds than the legal speed limit. Other causes of this

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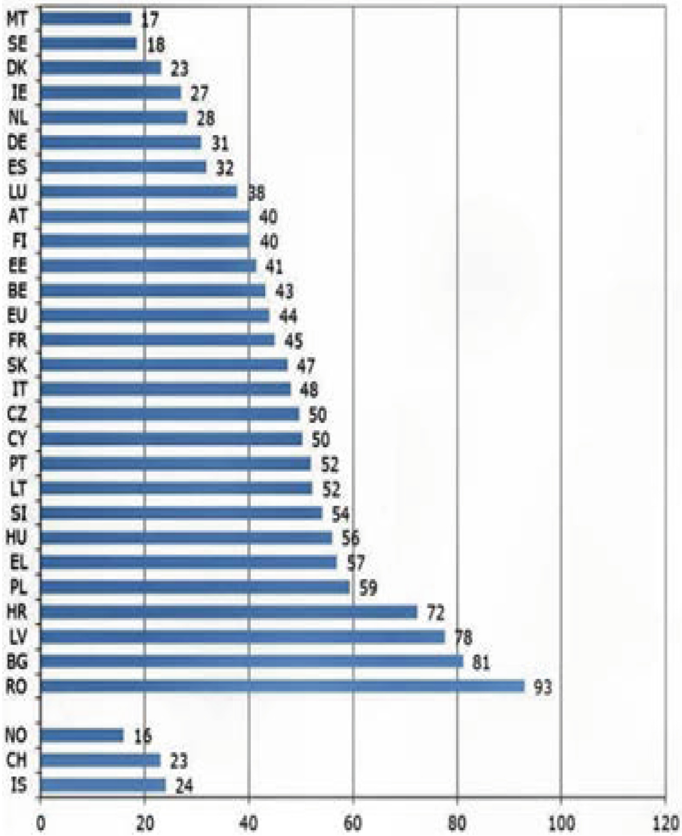

Fig. 1. Fatalities rates per million inhabitants [1].

unwanted situation, starting from the inadequate condition of the road network and continuing with the age of the car fleet, the weakness of the road education and the technical non-conformities of many vehicles registered in Romania. The technical condition of the vehicles imported in Romania contributes to the accentuation of the black statistics regarding the fatal black road accidents.

Of the second hand vehicles, those imported from the UK can cause specific problems, most of which arise from the compatibility of RHD (UK legal) with LHD (EU legal). Although the Romanian Senate adopted in March 2022 a bill banning the circulation of right-hand-drive (RHD) vehicles on public roads in Romania, this bill is still before the Chamber of Deputies, which has not yet adopted it, so there is no clear deadline for the law to come into force.

In this respect, according to the data provided by the General Inspectorate of the Romanian Police, 246 accidents were registered with 35 people dead and another 88 seriously injured in 2019. A year later there were 206 accidents, with 34 dead and 61 seriously injured, and In the first four months of 2021, there were 50 accidents with 11 dead and 11 seriously injured.

Table 1. The structure and main features of the experimental research sets.

#	Cars	Headlight specs.	Pedestrian Specs	Drivers
I	FORD Focus RHD	UK halogen low beam headlights	Black clothes	D1, D2, D3, D4, D5, D6
	BMW X3	EU full LED low beam headlights		
II	FORD Focus RHD	UK halogen low beam headlights	Black clothes	D1, D2, D3, D4, D5, D6
	BMW X3	EU full LED low beam headlights		
	VW T-ROC	UK halogen low beam headlights		
III	FORD Focus RHD	EU halogen low beam headlights	Black clothes and reflective vest.	D1, D2, D3, D4, D5, D6
	BMW X3	EU full LED low beam headlights		
	FORD Focus RHD	UK halogen low beam headlights		

Thus, the number of accidents involving right-hand drive cars exceeds 10% of all road accidents in Romania.

The statistics of the Romanian Auto Registry show that 29,000 such cars were imported in 2018 and 20,000 vehicles in 2019. All these were brought from Great Britain and Ireland [2].

To analyze the influence of RHD vehicles in specific EU traffic conditions (left-hand drive, right-hand traffic) compared to LHD-registered vehicles, on the visibility, perception and avoidance of potential pedestrian collisions, In dark traffic conditions, a series of experiments have been carried out which will be described below.

2 Methodology of Experiments

The main purpose of the experimental research was to determine the moment/distance from which a pedestrian, while crossing the unlit road, outside the locality, is detected.

The perception of the presence of the pedestrian being subjective, they used up to 6 different drivers, driving in turn 3 cars with different characteristics. The configuration of the experiments is presented in Table 1, this being suggested by information from reference [3].

Three different cars were used: Ford Focus (right-hand drive, and low beam headlight for UK or EU), BMW x3 and VW T-ROC. The configuration of the tests is presented in the Table 1.

Figure 2 shows the device used to adjust the headlights (center). On the right the headlight adjustment is EU compliant (right) and the headlight adjustment is UK compliant (left).

Fig. 2. Headlight adjustment device (center). On the right is the EU-compliant headlight adjustment and on the left is the UK-regulated one.

Fig. 3. One of the moments when Ford Focus RHD driver detected the presence of pedestrian.

The three separate vehicles (of which the Ford Focus RHD had two different headlamp configurations) were driven by six drivers aged 21 to 66, wearing or not wearing glasses, and therefore presumably with a dispersion of visual perception.

Several optical devices were used to capture images in the visible or infrared spectrum, from various positions, of the vehicle-pedestrian configuration at the time of detection of the presence of the pedestrian on the carriageway, in order to validate the subjective perception of the driver.

Thus in Figs. 3 and 4 we can see the moment of perception of the pedestrian by one of the drivers of the Ford Focus RHD with EU-adjusted headlights. Figure 5 shows another moment of perception of the pedestrian in the Ford Focus RHD with UK-adjusted headlights.

Fig. 4. A false moment of pedestrian presence detection by the Ford Focus RHD driver, with headlights set for UK.

Fig. 5. Other moment when the Ford Focus RHD driver detected the presence of the pedestrian with car headlights set for UK.

Fig. 6. Pedestrian visibility of one of the BMW X3 drivers with adaptive LED headlights.

Fig. 7. Pedestrian visibility placed right on the longitudinal axis of the road of one of the BMW X3 drivers with adaptive LED headlights.

Visibility of the pedestrian crossing, observed in the adaptive low beam LED headlights of the BMW X3 is shown in Figs. 6 and 7.

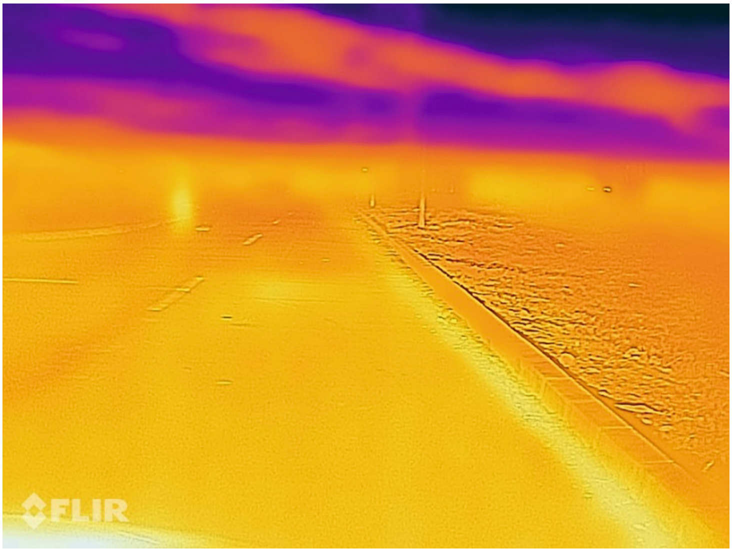

Fig. 8. Thermal camera observation of the moment of pedestrian detection by a Ford Focus RHD driver with headlights set to UK.

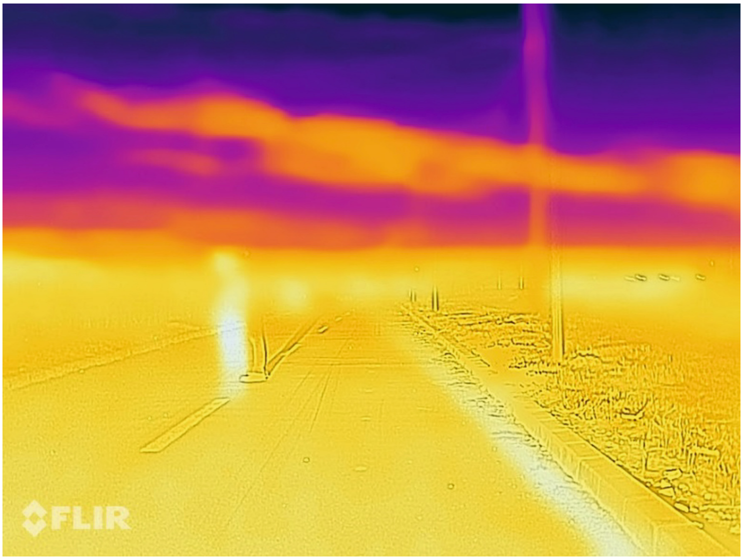

Fig. 9. Thermal camera observation of the moment of pedestrian detection by a Ford Focus RHD driver with headlights set to EU.

A thermal camera was also used to reduce the uncertainty of subjective observations [4]. In Figs. 8 and 9 are captured moments of the detection of the pedestrian crossing the road.

Fig. 10. Aerial verification of pedestrian detection by one of the BMW X3 drivers.

Fig. 11. Aerial check of pedestrian detection by one of the Ford Focus RHD drivers with UK headlights set up.

For a better objectification of the obviously subjective observations, Unmanned Aerial Vehicles (UAVs), known as drones, as can be seen in Figs. 10 and 11.

3 Results and Discussion

The pedestrian detection distance by drivers in each of the cases in Table 1 are shown in Table 2.

The perception of these distances was subjective, as in reality. Given that in each case the driver expected to detect the pedestrian at some point by the headlights, the element of surprise was missing from these determinations, which would probably have led to a reduction in the detection distance. On the other hand, given that the road under

Table 2. Tests results: the pedestrian detection distances.

#	Cars	Headlight specs.	The pedestrian detection distances [m]
I	FORD Focus RHD	UK halogen low beam headlights	D1 = 35, D2 = 36, D3 = 38, D4 = 36,5, D5 = 38, D6 = 38
	BMW X3	EU full LED low beam headlights	D1 = 41, D2 = 40, D3 = 39,2, D4 = 38, D5 = 43, D6 = 42
II	FORD Focus RHD	UK halogen low beam headlights	D1 = 35, D2 = 36, D3 = 38, D4 = 36,5, D5 = 37, D6 = 38
	BMW X3	EU full LED low beam headlights	D1 = 41, D2 = 40, D3 = 39,8, D4 = 38, D5 = 43, D6 = 42
	VW T-ROC	UK halogen low beam headlights	D1 = 25, D2 = 26, D3 = 21, D4 = 24, D5 = 22, D6 = 20
III	FORD Focus RHD	EU halogen low beam headlights	D1 = 35, D2 = 36, D3 = 38, D4 = 36,5, D5 = 37, D6 = 38
	BMW X3	EU full LED low beam headlights	D1 = 41, D2 = 40, D3 = 39,8, D4 = 38, D5 = 43, D6 = 42
	FORD Focus RHD	UK halogen low beam headlights	D1 = 25, D2 = 26, D3 = 24, D4 = 22, D5 = 25, D6 = 20

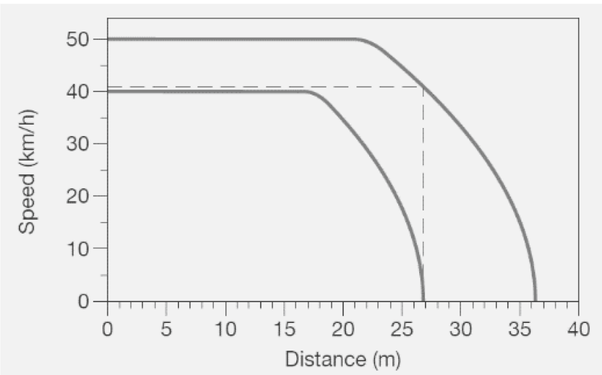

Fig. 12. Speed and stopping distance for emergency braking [6]

consideration was in total darkness, and outside the locality, the likelihood of a pedestrian crossing is quite low. All these considerations, which led to a reduction in the element of surprise, mean that in reality the distances recorded were probably overestimated.

4 Conclusion

Vehicle lighting systems are critical to the safety of night road traffic. The lighting system settings and the nature of the light source used, the position of the steering wheel (LHD - left hand driving or RHD - right hand driving) the visibility and subjective perceptions of the driver may be influenced the traffic safety.

Multiple cars and multiple systems were used in the work to detect and record perceptions and visibility. Various configurations were also used for the pedestrian in the crossing, but also for the driver of the vehicle, assuming an increase or decrease in visibility to the pedestrian in the case of low-beam headlights.

These experiments provided up-to-date information on the possibilities of avoiding road accidents in night-time traffic. The results obtained can also be used for a more accurate calibration of the emergency braking of driver assistance systems. In order to analyze the influence of right-hand-drive vehicles under specific EU traffic conditions (left-hand drive, right-hand traffic) compared to LHD-registered vehicles on the visibility, perception and avoidance of potential pedestrian collisions under night-time traffic conditions, subjective data validated by using a variety of recording systems placed at different positions relative to the driver-vehicle-pedestrian system were obtained.

The obtained results allow a validation adapted to the real life of the possibilities to avoid a collision by emergency braking as can be seen in Fig. 12 [6].

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