
The Impact of Using Vehicle Lighting during the Day on Road Safety - Selected Aspects

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Abstract:

Purpose: Road safety is an important sphere for public life. One of the elements influencing the level of safety is lighting of vehicles, which was the subject of the analysis.

Design / Methodology / Approach: The research was carried out by problem analysis and their synthesis.

Findings: The conducted analysis highlighted the enormous potential related to the impact of vehicle lighting on traffic safety.

Practical Implications: The problems described in the article may contribute to increasing awareness of the impact of lighting on road safety.

Originality: The article deals with issues and the sphere of public and economic life that are not discussed so often in scientific literature.

Keywords: Safety, road traffic, vehicle.

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1. Introduction

The dilemma resulting from driving with the lights on during the daytime has been a subject of discussion for many years (Błaszczuk, 2010) not only in Poland, but also all over the world, which resulted in many research works and experiments in the field of reducing the number of road accidents and their victims, as well as other aspects of the perception of cars with dipped headlights on by other road users. Aspects related to dazzling drivers as well as difficulties resulting from the correct perception of the traffic situation were also discussed. The concept of using dipped beam headlights in the daytime was born more than fifty years ago, and the first results confirming the purposefulness of such an action were noticeable in the Scandinavian countries, which are characterized by unfavorable conditions resulting from natural lighting, such as frequent fogs, a significant number of cloudy days, rain, snow, short daytime.

2. Review of Publications Based on the Analysis of Road Accident Statistics

Since 1964, (including) in the USA, Finland, Norway, Denmark, Sweden and Canada, a parallel analysis of studies on the impact of the use of dipped beam during the day on road safety was conducted (Podręcznik bezpieczeństwa drogowego, 2001). The main results of the research are presented in Table 1.

Table 1. *Impact of compulsory use of dipped headlights on the overall nb. of accidents (Błaszczuk, 2010)*

The results of accidents	Change in the number of accidents in %		
	Types of accidents which may be affected by the use of dipped-beam headlamps	Average of test results	Limits of variability of results depending on the country
Accidents with fatalities and injured	Collision involving a pedestrian	-15%	(-17% -13%)
	Collision involving a cyclist	-10%	(-15% -5%)
	Frontal or side impacts	-10%	(-12% -8%)

Source: Own study.

The research demonstrates that the danger of one driver being involved in an accident was reduced by an average of 13% when using dipped beam during the day. Based on these studies, it was found that introducing the obligatory use of dipped beam during the day would reduce the number of road incidents during the day by an average of 10-15% in among least 85-90% of drivers. The positive results of the research showed that driving during daytime with dipped headlights should be obligatory, which has become the reason for introducing such an obligation in most countries in Europe, at different times of the day, depending on the country.

On January 1, 1987, following the path of other countries, changes were also made to the road regulations of the former Soviet Union, as well as to the Republic of Belarus, which came into force at the beginning of September 1996. They contained requirements for the use of dipped headlights during the day to mark motor vehicles in the following cases: riding a motorcycle, moped, riding in a column, during the transport of organized groups of children, heavy and oversized vehicles, when transporting hazardous materials, and towing vehicles in towing vehicles. The dipped beam was also used during the annual action "Attention! Children!" To ensure the safety of pedestrians 5-10 days before the end and start of the school year.

On July 1, 2003, a provision was introduced in Belarus that required the use of dipped headlights in motor vehicles by day, in the period from November 1 to March 31 (Дрозд Н.Н., Шут А.Е, Об эффективности ближнего света фар, МВД Республики Беларусь, Минск). Initial results, five months after the introduction of this regulation, showed that the use of dipped beam during daytime has a positive effect in terms of road safety, as shown in Table 2. Statistical data show that in the period from November 2003 to April 2004, the number of accidents involving pedestrians during the daytime in Belarus, compared to the corresponding period of 2002-2003, decreased by 2.6%, frontal collisions of road users decreased by 7.3%, while collisions at intersections and road bends by 10.0%, and the number of fatalities decreased by 25.4%, and injured by 1.2% (Дрозд Н.Н., Шут А.Е, Об эффективности ближнего света фар, МВД Республики Беларусь, Минск).

According to the Belarusian authorities, driving with the dipped beam headlights on during the daytime significantly reduces the incidence of road accidents, mainly with pedestrians, and car accidents of the nature of frontal and side collisions, i.e., such accidents whose main cause is delayed detection of another traffic participant. The Ministry of the Interior of Belarus has set itself the goal of continuing the analysis of the impact of the use of dipped headlights during daylight hours on road safety.

Table 2. *Statistics of accidents in the Republic of Belarus for certain types of accidents in the period November - March 2002-2003 and 2003-2004*

Type of accident [1]	Index [2]	With the participation [3]	Head-on collision [4]	Collision at the intersection of roads and [5]	All types of road accidents [3+4+5]
All accidents by type	2003-2004	1492	219	131	1842
	2002-2003	1537	236	131	1904
	+ / - %	-2,9%	-7,2%	0%	-3,3%
Including during the day	2003-2004	453	114	72	639
	2002-2003	465	123	80	668
	+ / - %	-2,6%	-7,3%	-10,0%	-4,3%
Fatalities	2003-2004	386	78	12	476
	2002-2003	371	88	18	477
	+ / - %	4,1%	-11,4%	-33,3%	-0,2%

Including during the day	2003-2004	48	38	5	91
	2002-2003	63	46	13	122
	+ / - %	-23,8%	-17,4%	-61,5%	-25,4%
All injured	2003-2004	1200	376	204	1780
	2002-2003	1248	381	182	1811
	+ / - %	-3,8%	-1,3%	12,1%	-1,7%
Including during the day	2003-2004	425	198	101	724
	2002-2003	428	202	103	733
	+ / - %	-0,7%	-1,9%	-1,9%	-1,2%

Source: Own study.

The studies presented above were based mainly on the statistical analysis of the accident rate in the period when the dipped beam was used in the daytime in relation to the periods when there was no such obligation.

3. Review of Publications Based on Theoretical Analysis

To refer to the influence of the perception of other road users while driving, Helmers (1988) suggested that improving the visibility of vehicles by switching on the dipped beam will result in better conditions for their detection and better assessment of the traffic situation. These better conditions would increase the average detection distance and safety margins for vehicles on the road. In this regard, Helmers concluded that "the most important consequence for road safety is the reduction of the emergence of too short detection distances and too small safety margins in road traffic" (Helmers and Nilsson, 1988).

According to Helmers and Nilsson (1988), it is intuitively probable that if the use of dipped beam has some effect, it should result in a change in the visibility of the vehicle. However, the term was not very precise, nor was it clear how or in what sense the lights on would increase the safety margin. Since there was no coherent theory about the mechanisms that govern the daytime use of dipped headlights, one could only speculate on the effects of low beam on perception and therefore assume at least three different effects:

1. The dipped beam increases the visibility of vehicles.
2. Dipped beam as a permanent search function.
3. Dipped beam as a permanent identification feature.

1. The dipped beam increases the visibility of vehicles:

According to Engel (1977), visibility can be defined as the degree of perceptual significance of a visible object in its environment (i.e., how much it stands out) based on primitive sensory characteristics such as differences in brightness, color, outline, size, etc. As can be seen from this description, the visibility of an object is determined by factors from both the object and the background. For example, increasing the "clutter" in the background, or increasing the variability of physical characteristics

in the environment, can make the subject less visible. According to Conners (1975), Gerathewohl (1954), and Jenkins (1979) the most important property of visibility that is common to all definitions is that the visible object attracts attention.

Therefore, when analyzing the literature in this area, it was possible to notice the four most important issues. First, improved visibility is naturally seen as a greater likelihood of detecting a potential road user without intending to actively seek him out (Hughes and Cole, 1984). Secondly, the visibility of vehicles during the day is strongly dependent on the specific light conditions of the surroundings, the brightness and contrast of the vehicle colors and the background (Henderson *et al.*, 1983). Thirdly, according to Padmos (1988), the visibility of a vehicle depends mainly on its brightness and color contrast, and its size. For the dipped beam to contribute to the vehicle's visibility, its intensity should be well above the background illumination level (ambient luminance).

Obviously, this ambient luminance determines the intensity of the luminance of the light source needed to produce the light contrast. At low ambient light levels (dawn, dusk), low-intensity light should contribute to the light contrast, while at high ambient light levels (full sun) only high-intensity lights could contribute to the light contrast. Therefore, according to Padmos (1988), the degree to which the dipped beam contributes to the increase of visibility depends on the ratio of the intensity of the dipped beam (luminous intensity) and the intensity of the ambient light intensity. Fourthly, visibility includes the eye-catching features of an object or event, but also depends on factors such as motivation, previous experiences, and expectations (Henderson *et al.*, 1983).

2. Dipped beam as a permanent search function:

Hole and Tyrell (1995) argue that when an observer searches for a specific target, his attention may be selectively focused on some basic parameters such as color, shape and brightness. Therefore, coding the driving reference as a simple and constant feature, such as switching on a dipped beam, may facilitate the search for target vehicles. The search time for a possible vehicle can be short as attention can be selectively focused on that one feature. Of course, this can result in faster and more accurate detection of vehicles with dipped headlights on.

3. Dipped beam as a permanent identification feature:

The explanations so far have been related to the influence on the selection process, i.e., the processes that determine the place in the field of view where our attention is directed (eye fixation). When attention is drawn to a point in space, identification processes play their roles. Research has shown that objects that are unexpected, new, or unlikely to appear in each location cause eyesight to focus for a much longer time than expected objects. Consistent coding of objects with the dipped beam can facilitate this recognition process. It can therefore be expected that the attention span of vehicles with dipped headlights on is shorter than for vehicles without headlights

on, since awareness that the vehicle is a potential object on the road is greater and more precisely achieved (Antes and Penland, 1981).

4. Possible Negative Effects of Using Dipped Beam based on Literature

As noted, daytime visibility of vehicles is highly dependent on the degree of "competitiveness" of the background. If it is assumed that the dipped headlamps are to improve the visibility of the vehicle, road users without these headlamps will become less visible. By making the vehicle more visible by switching on the dipped headlights, it is unlikely that the level of visibility of other road users in terms of their perception will decrease (Henderson *et al.*, 1083). Visibility is not an absolute measure and is determined by both, the object, and the background. Special attention was paid to motorcyclists related to the dipped beam headlamps and their effect on the visibility of other road users.

Many countries require or recommend that motorcyclists use their dipped headlights during the day. If motorcyclists are visible during the day because they are the only road users with the dipped headlights on, it is likely that when the headlamps are mandatory for all road users, motorcyclists will become less visible. Considering visibility, should be assumed that a motorcyclist with the dipped beam headlamps on is more difficult to detect when all other vehicles also have the dipped beam on than if only the motorcyclist is on. Searching for a possible vehicle with the dipped headlights on can be quick as the observer's attention can be selectively adjusted to search for one specific feature, i.e., objects with the headlights on. While this may be beneficial for users with dipped beam headlamps on, it may also have negative consequences for those road users who do not use dipped beam headlamps.

As noted by Hörberg and Rumar (1979) "compared to vehicles that use lights, vehicles without lights will be more difficult to detect". The researchers say that because drivers may adopt a different car detection strategy from the one, they normally use during the day, e.g., the presence of two lights rather than the appearance of the shape of the vehicle, a vehicle without lights will be less visible than when no vehicle will have its dipped beam headlamps on under these conditions. Since the lights on provide a consistent feature to the driver search strategy, all vehicles without two headlamps may have lower probabilities of being detected than vehicles equipped with two low beam headlamps. As noted, dipped headlights on can function as a quick and accurate identification feature. Given these mechanisms, side effects are highly likely to appear. Quick and accurate identification of road users with dipped headlights on may be at the expense of slow and misidentification of road users not having headlights on. Consequently, misidentification means that the object is noticed but not recognized as a potential target. These errors are likely to identify pedestrians, cyclists and especially cars without dipped headlights or when the headlights are gradually being deployed.

5. Discussion of Results

The main result of these studies is the conclusion that no evidence has been found that the visibility of other road users near the car with the dipped headlights on, as measured by the speed of detection, the speed at which their presence is detected, is diminished due to the appearance of the car with the low beam headlights on. In fact, the evidence indicates an opposite effect - other road users benefit from the lights on, although the effect has been modest. The results do not provide any specific explanation of the effect obtained, but the issue is worthy of more discussion. It is debatable whether this result is due to faster detection of vehicles with dipped headlights on or off.

Another possible explanation is improved field of view organization due to the dipped beam. However, this study did not include the subjects' eye movement or any other specific variables that would approximate the answers to these questions. Consequently, these effects are solely speculative. Even though the impact of the use of dipped headlights during the day on the detectability of other road users has not been clearly noted, it may turn out that this impact may be negative in specific, hitherto unexplored conditions.

However, inspection of the significant interactions obtained related to the use of the dipped beam showed that this was not the case. It can be concluded that the lack of a negative effect on the detectability of other road users was a common phenomenon, at least in terms of the situations studied in the experiment. There is no evidence in these findings to support the thesis that there may be situations in which adverse effects of daytime passing beam headlamps may arise. A similar lack of adverse effects was found regarding the visual abilities of drivers, such as the results of the Beneficial Field of View and static visual acuity measured among older drivers.

Again, this is true both in general terms as well as with regard to the interactions that might arise in specific situations. As stated, there is no evidence that the low beam used during the day attracts the attention of respondents and directs it away from other road users. It may be argued that this may however occur in more complex situations, for example in those where the road user is surrounded by many vehicles with dipped beam headlights on. Of course, this possibility remains to be explored. It should be noted, however, that even the scenes that were used in these studies were varied in terms of complexity, which, however, did not adversely affect the on / off effect of the dipped beam headlights. If the dipped beam in any way overwhelms another road user, this should also appear in these test results.

6. Conclusions

Summarizing the analysis of the publications on the research carried out on the impact of the use of dipped headlights during the day on road safety, it should be

noted that when assessing the effects of road safety measures, one should always take into account the possibility that some categories of road users, due to some natural limitation of their abilities of information processing or decision-making skills will benefit less from a given safety measure than the average road user. From time to time, the safety effect may turn out to be negative due to the individual psychophysiological characteristics of road users. The characteristics of road users that are often determined in this regard are the age of the driver and his visual abilities. In particular, the combination of these two factors can lead to unsatisfactory safety effects. For example, Ball *et al.* (1993) showed that for drivers over 55 there is a clear relationship between their so-called A favorable Field of View, a measure of the ability to focus eyesight and their future involvement in a road accident.

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