

# Glare on Road Traffic

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## European consumer study 2024

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### A collaboration of 10 European mobility clubs

- Automobile Club du Luxembourg (ACL)
- Allgemeiner Deutscher Automobil-Club (ADAC)
- Avto-moto zveza Slovenije (AMZS)
- Koninklijke Nederlandse Toeristenbond ANWB (ANWB)
- Bosanskohercegovački auto-moto klub (BIHAMK)
- IAM RoadSmart (IAM, GB)
- Norges Automobil-Forbund (NAF)
- Österreichischer Automobil-, Motorrad- und Touringclub (ÖAMTC)
- Touring Club Royal de Belgique (TCB)
- Touring Club Schweiz (TCS)



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## Foreword Marga de Jager, CEO ANWB

Over the past few years we've seen a rise in from our members that modern headlights are causing issues for road users. To validate that these signals pointed to a broader issue we launched a comprehensive survey among our members. Within a short time period a large number of cyclists, pedestrians and car drivers gave us their feedback. The issue clearly resonated with a broad audience both young and old alike.

Almost 80% of respondents regularly encounter blinding lights. It causes road users to squint (60%) or even take their eyes of the road (72%). It also causes other road users with less bright headlights to be less visible. Our sister associations in nine other European countries have conducted similar research, the outcome of which is bundled in this report. Their surveys point to very similar outcomes to our survey. Along with other mobility clubs, united in FIA, we will discuss the findings of this report with both car manufactures to make adjustments to headlights, as well as policy makers in the European Commission in order for them to implement stricter regulation in the future. At ANWB we have always been at the forefront of advocating for road safety, and we believe that the outcome of this report can help in making our roads a safer place.



Marga de Jager  
CEO ANWB

## Foreword Karsten Schulze, Technical President ADAC

Road safety is at the heart of the efforts of transport experts and organisations worldwide. Significant progress has been and continues to be made. However, there is a need for action when it comes to glare from car lights and headlights, which is not only annoying but can also be dangerous for road users. The specifications for the design of lights and headlights must therefore take greater account of the risk of glare, especially under real road conditions in dense extra-urban and city traffic. From the optimisation of adaptive high beam systems to the personal responsibility of drivers, the focus is on taking measures to ensure the safety and comfort of all road users.

The ADAC mobility club is not only in favour of practical solutions but is also calling for further scientific studies to investigate the causes of glare in more detail and adapt the technical lighting test procedures on this basis. With the involvement of all stakeholders from industry, research, science and consumer protection, approaches and solutions must be found that ensure safety through good visibility on the one hand and low glare on the other.



Karsten Schulze  
Technical President  
ADAC e.V., Munich

## Motivation

More and more members are complaining about glare in road traffic, ranging from irritation to reports of near accidents. Although the number of incoming reports is still manageable, a fairly large proportion of drivers, especially when asked, report being disturbed by headlights and other lights.

Visibility is obstructed and perceiving objects or vulnerable traffic participants is made difficult. The inconvenience of driving in the dark is perceived as disturbing. Ten European automobile clubs therefore surveyed their members to find out exactly where the problems are and on what scale people experience annoyance.

This survey is not a scientific study on the effects of glare on the road. Unfortunately, there is hardly any, and if there is, it is somewhat older. It is also not well recorded as to whether glare plays a role in causing an accident. This is also quite difficult; immediately after the accident there are other priorities and only in very serious accidents has more investigation into the circumstances been done. A victim cannot always recount the circumstances properly either.

However, it is known that the recovery of the driver's eyes after glare can take **up to 9 seconds** (source: Royal Society for the Prevention of Accidents, UK). **That time covers a considerable distance without being able to see properly. At 30 km/h it is already 75 meters, at 50 km/h 125 meters and at 100 km/h even 250 meters.**

In previous questions about glare to authorities, two main causes were always mentioned:

1. Old age of the driver as cause of poorer eyesight and
2. poor headlight adjustment.

However, age does not play such a major role; the often-heard argument that older people in particular suffer from glare (and perhaps should stop driving) is completely debunked by the study.

Proper adjustment is certainly important, and automobile clubs take their responsibility to properly inform drivers. Headlight adjustment is done on many cars in the MOT or during maintenance. Although this check has improved with the times, complaints persist.

The growing number of traffic casualties is shocking. As a response, cars should have expensive driver assistance systems. However, there are probably easier and cheaper technical improvements by improving car lights.

## Study design

A large group of members of the FIA worked together on research as to how car drivers in Europe experience glare in road. ADAC and ANWB set up a questionnaire to distribute to members, and other mobility clubs joined that initiative. The goal was to find out, whether car drivers do experience any difficulties in glare, in order to propose solutions to the European Commission.

Two methods were used to collect the sample for the study. One was a representative sample and the other was inviting club members to participate. A similar questionnaire was used for both. ADAC undertook the study for Germany, Belgium, Austria, Switzerland and Luxemburg. Per country they recruited a representative sample of inhabitants (N > 1000 per country, Luxemburg > 400).

The ANWB gathered the results from Norway, Slovenia, Bosnia Herzegovina and the Netherlands. These countries conducted the study among their member base and ANWB gathered the results. The expectation was that people complain more when offered the opportunity.

That is also somewhat observable. The results of this study were unexpectedly in line with those in the ADAC report. Reactions in particular in the Netherlands were overwhelming. The ANWB survey can still be completed and already has almost 15.000 finished results. The report covers 13.640 respondents (13/11/2023).

The British club IAM Roadsmart used only some of the questionnaire. Additionally, RAC sent out a comparable survey in late 2023, covering 2,000 drivers. The result was that 89 % thought some or most car headlights on the UK's roads were too bright, with a majority of these (91 %) saying they got dazzled by them. In addition, 85% of those affected by glare said they believe the problem is getting worse. RAC has conducted research on the topic in the UK since 2018.

## Executive summary

Vehicle lighting is perceived as increasingly bright by members of 10 European automobile clubs. New technology, especially LED lighting, is making the road in front of the car increasingly bright. Unfortunately, this also has adverse effects and there are many complaints about this.

**The survey results unexpectedly showed that many people suffer from glare caused by vehicle lighting:**

- Glare seems to be quite an issue, with **8 out of 10 people experiencing this on a regular basis**. The majority would classify this as annoying or even unbearable.
- Discomfort is annoying, but some people even feel pain. **It is not only a subjective, mental problem.**
- **People are closing their eyes for a few seconds, or vision is blocked for a moment**, when they pay no attention onto the road or to other road users, while moving forward quite a distance.
- People get tired by blinding; this may decrease road safety.
- Some people feel their freedom is limited because they no longer drive their car in the dark.
- **8 out of 10 drivers believe that glare prevention should be better regulated.**
- 4 out of 10 drivers even think that glare from car lights should be regulated as a high priority.
- Age is not a main factor in the results; **youngsters seem to experience the same discomfort as elderly people**, despite elderly people having more physical reasons for this.

*This study is not an indictment of new types of vehicle lighting, such as LED lighting; this is widely used and has many advantages. However, its clear disadvantages need to be reduced, for which the current regulations are not adequate. We call for an examination as to whether the current UNECE rules regarding vehicle lighting are suitable for the newest generation of beamers and lights and their functionality.*

*In our opinion, these rules should be adapted, so the new technologies can be used safely way. Several technical solutions can be devised to achieve this. The joint automobile clubs request the European Commission to further investigate and then discuss the possibilities with car manufacturers.*

## Voices of drivers

The mobility clubs received thousands of comments of the participants in the survey. To give an impression of the perception of glare on the road, here are some examples, which represent the responses:

- “Apart from the far too bright light, **the colour is also a problem**. From intense white, it suddenly changes to a blue flash, as if a blue flashing light is approaching. Very confusing. 2nd issue are the tall SUVs. The intense white and bright light is so high that it shines straight into the mirrors. Extremely annoying.”
- “The balance between “seeing and being seen” is gone. **Car lights have become so bright that other road users are (almost) invisible**. The one who gets to drive the brightest headlights has the best visibility, those around are overruled by a large amount of light, which literally blinds.”
- “Bright lights are not a perception, but a fact. The lights may be legally adjusted correctly in principle, but the light output has increased tenfold and if that “escapes” the oncoming light is severely blinded. Lumen count has to go back.”
- “I find it strange that such blinding official lights on cars and electric bikes are just allowed while it is dangerous.”
- “I often find the current car lighting very irritating. **It seems like some vehicles are constantly running high beams**. And the adaptive/self-thinking lights are also irritating. Sometimes it looks like flashing disco lights. Up for improvement/fine-tuning.”

- “In fact, I think that numerous one-sided accidents at night on the country road are due to those light cannons of the oncoming traffic, which simply make it impossible to see the road in front of you. In rain, it is then even more dangerous!”
- “Indeed, there seem to be more and more blinding lights. It bothers me, you see "nothing" for a while anyway.”
- “A tried and tested interrogation method used to be used. The suspect was placed on a chair facing a bright lamp. Behind the lamp were the interrogators. Who and how many they were was a mystery to the suspect. Perhaps the executioner was also standing there. The suspect was already thrown off guard in this way. Something similar is happening in traffic now with the current lighting.”
- “These days, I avoid driving in the dark because there is so much annoyingly high backlight. I don't think anyone has heard of dimming or it's not in the lights.”
- “LED lights have improved visibility for the car driver himself. However, some are so bright, especially from taller cars so you can't see anything anymore.”
- “I was recently so blinded by lights from the car behind me that I automatically looked in my mirror. As a result, I drove hard into the pavement and had a burst tire.”

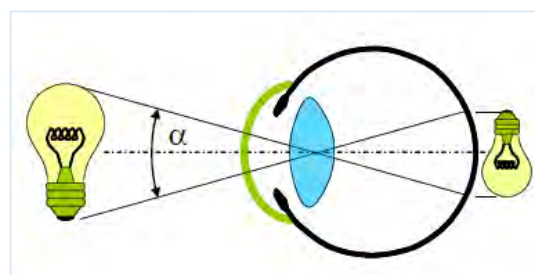
## Possible causes and effects

Recent thorough European research on the link between glare and accidents is poor. US research shows that there is a link between glare from lights and road accidents. This is also logical, since there is irritation and distraction and drivers drive with reduced or no vision for a number of seconds. This link should be further investigated in a scientific way to help halt or even reverse the rise in road casualties. The fact that 8 out of 10 vehicle drivers report being hindered by glare is alarming.

Conversely, by the way, it has not been shown that improved visibility for drivers of a vehicle with brighter lighting leads to fewer casualties. Nevertheless such brighter lighting is already in use. This study shows that there are disadvantages for other road user, that might equalize advantages of better performing headlights. Glaring break-lights and rear fog-lights can reduce the view of obstacles around the glaring light source.

Respondents almost unanimously mention that they bothered by, or even suffer from, the brighter light of modern vehicle lightning. The brightness is caused by the smaller dimensions of headlight units. We think there should be a minimal dimension for these lights to stop this.

The requirements for approval of vehicle lights are set in illuminance values of the light beam and the light distribution. The (human) eye instead “measures” luminance and contrast. Due to the construction of the eye, it copies a sharp picture of the light source in all details onto the retina. The higher the luminance of the light source and the sharper the contrast in the light source, the more side effects occur in the eye. Additionally, the cells on the retina are very sensitive to blue light, which increases the side effects like glare with light sources, which have a high part of blue light in their light colour distribution. Last but not least, the eye is much more sensitive and the range for brightness is much higher than at any camera system (up to 140 dB), the viewing angle is much smaller (lower than 1/60 degrees; detecting objects in size of almost 1 cm at 50 m distance). That makes it difficult to measure light beams with technical devices in comparison with the (human) eye and to simulate effects onto the eye and inside of it. It is therefore recommended to take account of the perception of road users, as set out in this survey of the mobility clubs.



The angular extent  $\alpha$  characterises the size of the source on the retina. The smaller  $\alpha$ , the smaller the image of the source on the retina. As the luminance must be increased for the same light performance on the road with a smaller angle  $\alpha$ , it is also higher on the illuminated part of the retina. | Source: Seibersdorf Laboratories, AUVA-Report Nr. 53 Optische Strahlung

Research by Benedikt Kleinert, IAV (“Blendungsbewertung von Kfz-Scheinwerfern”, 2013) mentions the absence in the UN regulations of any requirements of the light distribution of headlights in relation to the dynamic conditions in the driving process, which leads to glare. Additionally, he pointed to the research of Alferdinck (“Discomfort glare of car headlamps: evaluation of the effects of luminous intensity, size, colour, and configuration”, 1999), that proves the influence of luminance to glare

perception. However, it should be noted that in the time of that research there had been no LED light sources with such high luminance.

An easy solution to prevent glare has already been used by a few car manufacturers. They use a reflector system to assure that the light beam is not too concentrated, it reduces the luminance at the level of the headlight cover and thus in the perception of the observer of the glare source. A long time ago, a ring of light was placed around the bright xenon light source to reduce the contrast and the glare effects. A study could show which measures would lead to a significant improvement and should be obligation in future.

John D. Bullough of Icahn School of Medicine at Mount Sinai plotted 2002 De Boer ratings from halogen, blue-filtered halogen and HID headlamps providing different illuminances at the eye, as a function of relative short-wavelength cone stimulation and found that the resulting De Boer ratings were highly correlated with this quantity. Also, a research of Sivak/Schoettle/Minoda/Flannagan of The University of Michigan Transportation Research Institute (“Blue Content of LED Headlamps and Discomfort Glare”, 2005) proved a relation between glare perception and light temperature (which is strongly correlated with blue content over the range of interest; cold means higher light temperature) — the colder the higher.

Respondents often mention SUVs and vans as source of glare. The fact that the study participants specifically named these cars but not trucks, is remarkable, but might be because there are rules for the height of headlights in trucks. The angle between the view to the road and the glaring light source is smaller than for normal cars. The high position of the headlights can also glare into the back mirrors of the car in front in city traffic.

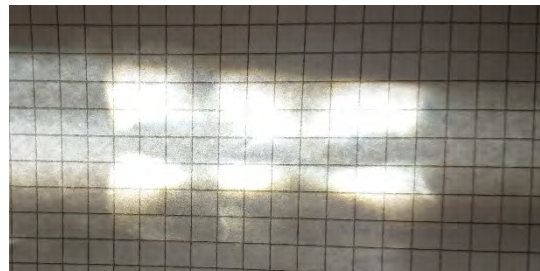


Illustration of the light emission of a modern LED lowbeam headlight with very high luminance: each box measures 5x5 mm. The light emission area perceived by the eye is only around 5 cm<sup>2</sup> in total. | Source: ADAC e.V.

Discomfort is annoying, but some people feel pain, and this is a physical problem. UK opticians argue that many patients don't have an eye problem, but were nevertheless bothered by glare. The main problem of glare in traffic is the pitching movements of the vehicles and thus the significantly higher illuminance levels at the eye than those permitted by law in point B50L or zone 3. This not only drastically reduces contrast vision at the moment of glare, but also results in a significant loss of visual performance due to the necessary dark adaptation after the immediate glare.

A study conducted by Prof. Dr.-Ing. Tran Quoc Khanh at Darmstadt Technical University has shown that adaptive high beam causes more glare than normal low beam – if the headlights are clean. However, if the cover is dirty, it is no longer guaranteed that the objects are correctly cut out without glare. This increases the glare considerably.

There are indications that light sources with high luminance and a high proportion of blue light at close range can cause damage to the eye. There are still few studies on this, as today's luminance levels have only recently become available thanks to the latest LED technology. Unlike long-wave light, blue light produces chemical reactions on the retina that can lead to damage. However, it must be taken into account that the main beam of light can be viewed directly in front of the headlamp, either by passers-by when the vehicle is stationary or during maintenance work on the vehicle. The risk of injury must be safely excluded.

## Conclusions

**The results of the survey have shown that glare in road traffic is not a phenomenon of hypersensitive individuals, but that the majority of drivers feel dazzled in road traffic.** Furthermore, the answers show that it is not just a purely psychological glare, but that there has long been a physiological glare, because afterimages, light haze and pain sensations are signs of a reaction of the sensory organ of the eye to (too) strong light entry emission with high luminance in the eye and on the retina.

**Over ¾ of all respondents were in favour of amendments to the legal regulations to reduce glare in traffic.** That is a clear vote in favour of actively taking measures. A new assessment is needed as to what extent the lighting technology used increases road safety through improved visibility and being seen better as against the extent it reduces road safety through glare and the reactions of other car drivers which can be dangerous.

**Intuitive reactions such as squinting or even briefly closing the eyes, frequent blinking as well as looking directly into the dazzling light source are to be classified as dangerous to traffic. As well as the frequent statement that objects around the dazzling light source are difficult to recognize.**

The assumption that glare is predominantly a problem for older people due to the ageing of the eye and the associated visual impairment was not confirmed by the survey. On the contrary, the proportion of younger drivers who feel dazzled is significantly higher.

The results of the survey were presented to Prof. Dr. Dr. Bernhard Lachenmayr, specialist in ophthalmology who was not surprised by the findings. The ever smaller light-emitting surface and the increasingly higher luminance increase psychological and physiological glare. Dr. Ucke and Prof. Hartmann (Institute for Medical Optics at the LMU Munich, now the Chair of Bio Molecular Optics) were able to prove this by applying Holladay's glare formula through impressive measurements, according to Prof. Lachenmayr.

In 2023, a pilot study was carried out at the TU Darmstadt in the Department of Adaptive Lighting Systems and Visual Processing under Prof. Dr.-Ing. Tran Quoc Khanh. This also showed a correlation between glare and luminance of the glare source.

## Recommendations

The results of the survey indicate that the current approval requirements within the framework of the UN ECE approval procedure are insufficient to protect road users from glare. The automobile clubs therefore recommend:

- The **specifications for the design of lights and headlamps used in road traffic must take greater account of the risk of glare for road users.** In particular, real road conditions must be taken into account in which the observer comes into the main beam of the headlights, looking at distances and viewing times in dense out-of-town and urban traffic (uneven road surfaces, bends, crests, stopping times at junctions, etc.), as well as the issue of misaligned headlights.
- **Adaptive high beam systems must be designed in such a way that road users of all kinds, including drivers of turning and crossing vehicles, cyclists and pedestrians, are recognized and not dazzled.** It must not be assumed that adaptive high beam systems will be manually deactivated if they dazzle.
- **The luminance of light sources must be limited,** both at a distance and at close range, in order to reduce glare and exclude the risk of injury to the eye at close range (e.g. in stationary traffic, children crossing in front of standing vehicles, etc.; compliance with and review of German § 30 StVZO Para. 1).
- The transition from "light" to "dark" should be soft in order to give the observer's eye more time to react to the change when immersed in the light cone. Contrasts in the immediate area of the luminaire should also be limited, for example by arranging light fields with decreasing luminance directly around the main light source. The very high resolution and dynamics of the eye must be taken into account, as well as the fact that the size and brightness of the light source are precisely mapped on the retina where high illuminance levels are achieved there corresponding to the luminance of the light source.
- Due to the high scattering effects caused by soiling in headlamps with high luminance in the area of the headlamp cover and the associated glare potential, **effective headlamp cleaning systems and automatic headlamp levelling systems should be mandatory** as a matter of principle, but at least when a specified luminance is exceeded in the area of the headlamp cover.
- The clubs suggest that **further studies should be carried out** to investigate the causes of glare in more detail, to determine limit values for illuminance and luminance and to justify them on the basis of scientific findings on the glare effect in the eye. Due to the high scattering effects caused by soiling in headlights with high luminance, the lighting test and measurement procedures for lights should be adapted accordingly.
- Through campaigns, road users should be informed about what they can do to minimize glare in road traffic and how they can react appropriately if they are dazzled.



## List of Attachments

- A: ADAC report of representative survey on glare on road traffic (summary ACL, ÖAMTC, TCB, TCS, and ADAC)
- B: ANWB report of survey on glare on road traffic, summarised results AMZS, ANWB, Bihamk, IAM Roadsmart and NAF. Club members were invited to give their opinion, a high number of entries was the result. Same questionnaire as “A”.
- C: ANWB results of the survey vehicle lighting 2023. Answers given by the 13.640 respondents who gave in October-November 2023 their opinion on modern vehicle lighting. Canals used were ANWB club’s magazine “Kampioen” and social media. Same questionnaire as “A”.
- D: RAC report of survey on glare on road traffic: When it comes to the effects of glare on drivers, two-in-three (67%) who suffer say they have to slow down considerably until they can see clearly again, while a similar proportion (64%) believe some headlights are so bright they risk causing accidents. In fact, five per cent of these drivers state they have nearly been involved in a collision themselves.
- E: Short summary of a study of TU Darmstadt on glare of ADB in clean and in dirty condition

## References

- This is how dazzling LED headlights really are: Many drivers complain about excessively bright lights in oncoming traffic. But are LED lights to blame? ADAC technicians wanted to find out more and analysed various LED headlamp systems. The result: some do indeed dazzle unnecessarily. [www.adac.de/rund-ums-fahrzeug/ausstatu ng-technik-zubehoer/licht-und-beleuchtung/blendung/](http://www.adac.de/rund-ums-fahrzeug/ausstatu ng-technik-zubehoer/licht-und-beleuchtung/blendung/) (German)
- A glaring problem: RAC calls for action on headlight glare as eight-in-10 drivers affected say problem is getting worse. An RAC survey of 2,000 drivers found a huge nine-in-10 (89%) think at least some headlights on cars on the road today are too bright, of which three-in-10 (28%) – a higher proportion than ever – think most are. Of the all these drivers who complain about the brightness of car headlights, some 91% say they get dazzled when driving with three-quarters (74%) saying this happens regularly: <http://media.rac.co.uk/pressreleases/a-glaring-problem-rac-calls-for-action-on-headlight-glare-as-eight-in-10-drivers-affected-say-problem-is-getting-worse-3296130>
- Why Road Users Crash at Night: Between the ages of 15 and 65, the time it takes to recover from glare increases from 1 to 9 seconds. This could be the reason why some people find driving at night more difficult. Young drivers who have not built up experience of night time driving are especially more susceptible to collisions at night. [www.rospa.com/rospaweb/docs/advice-services/road-safety/drivers/driving-at-night.pdf](http://www.rospa.com/rospaweb/docs/advice-services/road-safety/drivers/driving-at-night.pdf)
- Blinded by Brighter Headlights? It’s Not Your Imagination. The rising use of light-emitting diodes and the popularity of pickups and S.U.V.s have prompted complaints about the glare and intensity of headlights: [www.nytimes.com/2021/06/05/business/led-hid-headlights-blinding.html](http://www.nytimes.com/2021/06/05/business/led-hid-headlights-blinding.html)
- Study on the Influence of Opposing Glare from Vehicle High-Beam Headlights Based on Drivers’ Visual Requirements: In the USA, the number of traffic accidents caused by glare from the high-beam headlights of oncoming traffic at night accounts for 12 per cent to 15 per cent of all traffic accidents. See [www.ncbi.nlm.nih.gov/pmc/articles/PMC8910091/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC8910091/)
- Michael Sivak, Brandon Schoetl e, Takako Minoda, Michael J. Flannagan “Blue Content of LED Headlamps and Discomfort Glare”, 2005, The University of Michigan Transportation Research Institute: This study evaluated the effect of blue content of headlamps on discomfort glare, in order to provide guidance regarding spectral compositions that would minimize driver complaints. Ratings of discomfort glare were linearly related to the amount of blue content in the light output as weighted by the spectral sensitivity of the short-wavelength (blue) cone photoreceptors. <http://deepblue.lib.umich.edu/bitstream/handle/2027.42/57444/98625.pdf>
- Benjamin Kleinert, IAV „Blendungsbewertung von Kfz-Scheinwerfern – Was wird messtechnisch erfasst und was nicht?“, 2013: Studies have shown that different headlights have a comparable glare potential under static conditions. However, in a dynamic situation, as is also the case in reality, the behaviour is different. In addition, the mounting height is not included in the type approval of the headlamp. The influence of reflection from the road surface is also not taken into account. <http://www.tu->

[ilmenau.de/fileadmin/Bereiche/MB/lichtechnik/Literatur/2013/Kleinert\\_Luxjunior\\_2013.pdf](http://ilmenau.de/fileadmin/Bereiche/MB/lichtechnik/Literatur/2013/Kleinert_Luxjunior_2013.pdf)

(German)

- Stephan Völker „Blendung durch Kfz-Scheinwerfer im nächtlichen Straßenverkehr“, 2017, Technische Universität Berlin: One of the most common causes for traffic accidents during night-time is the restricted vision and ability of recognition. The long unanswered question of whether the glare luminance or the size of the illuminated headlamp surface has an influence on glare can be answered with "yes" on the basis of the investigations carried out. This study proposes a model for assessing psychological glare, which is based on the Unified Glare Rating (UGR) and could lead to a general glare judgement index in the future. The material could help to prevent traffic accidents. [http s://depositonce.tu-berlin.de/bitstreams/b7b6b184-ff3d-4e7e-a88b-62f56d6a04f9/download](http://depositonce.tu-berlin.de/bitstreams/b7b6b184-ff3d-4e7e-a88b-62f56d6a04f9/download) (German)

## Contact

Harm Zeven

ANWB B.V.

[hzeven@anwb.nl](mailto:hzeven@anwb.nl)

Burkhard Boettcher

ADAC e.V.

[burkhard.boettcher@adac.de](mailto:burkhard.boettcher@adac.de)

# Attachment A

ADAC report of representative survey on glare on road traffic  
(summary ACL, ÖAMTC, TCB, TCS, and ADAC)



## Consumer survey Glare in road traffic

**The issue is not new:** even when xenon headlights were introduced a few decades ago, drivers complained about the small, bright and almost daylight-white light source. The remedy back then was to place a less bright ring around the bright light source in order to reduce the harsh contrast between the light source and its surroundings – the so-called "angel eyes" were born.

LED technology dominates today. The ever smaller light sources score highly in terms of vibration resistance, high efficiency and new possibilities for generating variable light images. These tiny, light-emitting semiconductors can be controlled directly by modern electronic assemblies, high voltages are not required, currents and temperatures are moderate. Micro LED arrays generate variable cones of light similar to a modern projector for presentations at conferences. However, signaling lights on vehicles can also be made smaller; even a single high-power LED can form a rear fog light or a daytime running light.

But the **complaints are increasing.** This survey was developed together with other FIA clubs, with the ANWB as another key player, in order to determine whether it is a matter of individual, particularly sensitive people or a phenomenon that affects a large proportion of drivers and road users and ultimately even impairs road safety. In the end, **10 European mobility clubs took part** in the survey.

Two ways of asking motorists for their vote were implemented:

- ANWB (Netherlands), IAM (England), BIHAMK (Bosnia-Herzegovina), AMZS (Slovenia) and NAF (Norway) called on their members to complete the 6-page questionnaire online via their media such as member magazines, online and social media presences. Around 22,000 members responded to the call.
- The ÖAMTC (Austria), TCS (Switzerland), TCB (Belgium) and ACL (Luxembourg) joined the ADAC in conducting a representative survey via a market research company. The difference: not only do those who feel blinded give their opinion, but a structured and supervised survey of a good 1,000 drivers in each case, taking into account the demographic balance (just under 500 in Luxembourg).

The comprehensive **survey of motorists** was conducted up to the end of 2023 to determine the extent to which they are affected by glare from light sources on vehicles and what restrictions they experience when driving. To summarise, the representative survey conducted by a market research institute came to the following conclusions for **Belgium, Germany, Austria and Switzerland:**

- 71 % find the glare intolerable or annoying
- 32 % almost always or regularly feel dazzled
- 51 % of respondents pinch their eyes shut or even close them briefly
- 58 % have problems perceiving objects in the vicinity of the dazzling light source\*
- 30 % stated that they continued to see an image of the light source for a limited time after passing it (afterimage), or even felt pain\*

\*Indication of physiological glare and restriction of perception/vision

**75%** of those surveyed consider it necessary to review and update the regulations on reducing glare from vehicle lighting. The survey thus gives the **mobility clubs a clear mandate to take action to protect consumers** and introduce measures that ultimately lead to less glare in road traffic.

## The most important survey results

A total of 4,312 people were representatively interviewed from Germany, Austria, Switzerland and Belgium, while 447 people were interviewed in Luxembourg. The survey results described, represent the representative part of the survey.

<b>Do you feel dazzled by the lights of other vehicles?</b>	% ADAC (Germany)	% ÖAMTC (Austria)	% TCS (Switzerland)	% TCB (Belgium)	% ACL (Luxembourg) <i>(not representative)</i>	% Ø D/A/CH/B
<i>(only 1 answer possible)</i>						
almost always	5	5	7	6	6	6
regularly	22	26	29	28	31	26
sometimes	50	48	49	44	42	48
rare	15	15	11	13	17	14
almost never	6	4	3	6	4	5
never	2	1	1	1	< 1	1
Other / don't know	2	< 1	< 1	1	-	1

<b>How do you experience glare from other vehicles?</b>	% ADAC (Germany)	% ÖAMTC (Austria)	% TCS (Switzerland)	% TCB (Belgium)	% ACL (Luxembourg) <i>(not representative)</i>	% Ø D/A/CH/B
<i>(only 1 answer possible)</i>						
Unbearable	5	5	6	8	10	6
Disturbing	62	65	65	68	61	65
Just tolerable / permissible	26	25	25	16	21	23
Acceptable	2	1	1	5	2	2
Just noticeable	4	4	3	2	6	3
Other / don't know	5	1	< 1	1	< 1	1

<b>Can you describe the effect you feel when you are dazzled by lights?</b>	% ADAC (Germany)	% ÖAMTC (Austria)	% TCS (Switzerland)	% TCB (Belgium)	% ACL (Luxembourg) <i>(not representative)</i>	% Ø D/A/CH/B
<i>(multiple answers allowed)</i>						
Light scattering / light curtain	21	18	19	16	21	18
Everything around the light source is difficult to recognise	60	61	55	56	67	58
Light spot in the field of vision, that only disappears slowly (after-image)	23	25	23	33	17	26
Irritation	33	38	27	22	28	30
Pain	4	5	4	4	3	4
Miscellaneous	1	1	2	< 1	2	1
I do not know	8	4	5	7	3	6

<b>How do you react when you are confronted with a blinding light?</b>	% ADAC (Germany)	% ÖAMTC (Austria)	% TCS (Switzerland)	% TCB (Belgium)	% ACL (Luxembourg) <i>(not representative)</i>	% Ø D/A/CH/B
<i>(multiple answers allowed)</i>						
I look directly into the light source	3	4	4	5	5	4
I look away / in a different direction	48	40	43	41	55	43
I squint my eyes to minimise the glare	48	50	53	49	42	50
I close my eyes	2	1	1	2	1	2
I have to blink quite often (frequent blinking)	18	17	13	13	9	16
there is no reaction / I can ignore it / I don't behave differently	14	17	15	15	13	15
Miscellaneous	2	3	3	3	7	3
I do not know	3	1	1	2	< 1	2

<b>Does glare from lights have any other effects on you?</b>	% ADAC (Germany)	% ÖAMTC (Austria)	% TCS (Switzerland)	% TCB (Belgium)	% ACL (Luxembourg) <i>(not representative)</i>	% Ø D/A/CH/B
<i>(multiple answers allowed)</i>						
No, there are no other effects	49	55	55	56	53	54
I am stressed or annoyed	23	24	19	20	24	21
I get tired or have other physical problems	5	4	6	6	7	5
I drive less in the dark	22	17	20	18	18	19
I use special glasses to have less glare	4	4	4	4	8	4
I have completely stopped driving in the dark.	4	2	3	3	1	3
Miscellaneous	1	1	1	< 1	1	1
I do not know	5	4	2	4	1	4

<b>Do you think it is necessary to review and update the regulations on reducing glare from vehicle lighting?</b>	% ADAC (Germany)	% ÖAMTC (Austria)	% TCS (Switzerland)	% TCB (Belgium)	% ACL (Luxembourg) <i>(not representative)</i>	% Ø D/A/CH/B
<i>(only 1 answer possible)</i>						
Yes, very important	39	39	35	41	48	39
Yes, but it is not a high priority	34	36	40	37	30	37
Not required	20	20	20	17	20	19
Other / I don't know	7	5	5	5	3	6

<b>Which individual light sources from other vehicles dazzle you when driving?</b>	% ADAC (Germany)	% ÖAMTC (Austria)	% TCS (Switzerland)	% TCB (Belgium)	% ACL (Luxembourg) <i>(not representative)</i>	% Ø D/A/CH/B
<i>(multiple answers allowed)</i>						
Low beam	41	36	39	28	39	36
High beam (also adaptive)	82	89	74	77	75	81
Daytime running light	7	7	9	9	9	8
Brake light	9	6	8	7	9	7
Rear light	6	4	4	3	3	4
Direction indicator	2	1	2	3	2	2
Rear fog light	27	31	30	21	58	27
Blue light from emergency vehicles	9	8	8	10	7	9
Bicycle lighting	9	4	10	17	12	10
Miscellaneous	1	2	2	1	3	1
I do not know	4	2	2	4	1	3

<b>Under what visibility conditions do you feel dazzled?</b>	% ADAC (Germany)	% ÖAMTC (Austria)	% TCS (Switzerland)	% TCB (Belgium)	% ACL (Luxembourg) <i>(not representative)</i>	% Ø D/A/CH/B
<i>(multiple answers allowed)</i>						
Good visibility	4	6	9	7	12	7
Difficult visibility conditions such as low sun, sun glare, twilight	58	55	52	69	45	59
Poor visibility conditions such as darkness, fog, heavy rain, snow-fall	76	74	74	62	75	71
None of these	5	4	3	5	3	4
Other / don't know	2	1	1	2	< 1	1

<b>Do you think that vehicle lighting has improved visibility at night in the last 10 to 15 years?</b>	% ADAC (Germany)	% ÖAMTC (Austria)	% TCS (Switzerland)	% TCB (Belgium)	% ACL (Luxembourg) <i>(not representative)</i>	% Ø D/A/CH/B
<i>(only 1 answer possible)</i>						
Very much improved	14	26	20	12	44	18
Improved	51	50	54	49	43	51
Not improved, not deteriorated	24	16	18	22	8	20
Deteriorated	4	3	4	9	3	5
Severe deterioration	< 1	< 1	< 1	1	1	1
I do not know	7	4	4	7	2	6

## Conclusions

The results of the survey have shown that glare in road traffic is **not a phenomenon of individual** hypersensitivity, but that the majority of drivers feel dazzled in road traffic. The answers also show that it is not just a purely psychological perception of glare, but that **physiological glare** has long been present, as afterimages, light haze and painful sensations are signs of a **reaction of the eye's sensory organ to (too) strong light immission with high luminance** in the eye and on the retina.

Three quarters (75%) of all respondents were in favour of amending the **legal regulations to** reduce glare in road traffic. This is a **clear vote in favour** of taking action and actively implementing measures. The extent to which the lighting technology used increases road safety through better visibility and view or reduces it through glare and the reactions it causes in drivers, some of which are dangerous, must be reassessed.

**Intuitive reactions** such as squinting or even briefly closing the eyes, frequent blinking as well as looking directly into the dazzling light source are dangerous, as is the finding that objects around the dazzling light source are difficult to recognise.

The assumption, that glare is predominantly a problem for older people due to the ageing of the eye and the associated reduction in vision was not confirmed by the survey. On the contrary, **the proportion of younger drivers who feel dazzled is noticeably higher.**

The results of the survey were presented to Prof Dr Bernhard Lachenmayr, a specialist in ophthalmology, who was not surprised by the findings: **"The ever smaller light-emitting surface and the increasingly higher luminance increase psychological and physiological glare."** According to Prof Lachenmayr, Dr Ucke and Prof Hartmann (Institute for Medical Optics at the LMU Munich, now the Chair of BioMolecular Optics) were able to prove this with careful measurements using Holladay's glare formula.

In 2023, a study was carried out at TU Darmstadt in the Department of Adaptive Lighting Systems and Visual Processing under Prof Dr Tran Quoc Khanh, which also showed a correlation between glare and luminance of the glare source.

## Recommendations

The results of the survey indicate that the current approval requirements under the EU type approval procedure are inadequate to provide road users with sufficient protection against glare. The ADAC therefore recommends

- The specifications for the design of lights and headlamps used in road traffic must **take greater account** of the **risk of glare for road users**. In particular, real road conditions must be taken into account in which the observer comes into the main beam of the headlights, such as situations, distances and viewing times in dense out-of-town and urban traffic (uneven road surfaces, bends, crests, stopping times at junctions, etc.), as well as looking at potentially misaligned headlights.
- **Adaptive high beam systems** must be designed in such a way that all road users, including drivers of turning and crossing vehicles, cyclists and pedestrians, are recognised and not dazzled. It must not be assumed that adaptive high beam systems will be deactivated manually if they dazzle.
- The **luminance of light sources must be** limited, both at a distance and in the near field, in order to reduce glare in road traffic and exclude the risk of injury to the eye in the near field (for example in stationary traffic, children crossing in front of vehicles, etc.; compliance with of German § 30 StVZO para. 1).
- The **transition from "light" to "dark"** should be soft in order to give the observer's eye more time to react to the change when immersed in the light cone. The contrasts in the immediate area of the luminaire should also be limited, for example by arranging light fields with decreasing luminance directly around the main light source. The very high resolution and dynamics of the eye must be taken into account, as well as the fact that the size and brightness of the light source are precisely mapped on the retina, so high illuminance levels corresponding to the luminance of the light source(s) are achieved there.
- Due to the high scattering effects caused by **dirt on headlamps** with high luminance and the resulting glare, effective headlamp cleaning and automatic headlamp levelling mechanisms must always be prescribed, at least if a specified luminance is exceeded in the headlamp.



- The ADAC calls for that **further studies** to investigate the causes of glare in road traffic in more detail, to determine limit values with regard to illuminance and luminance and to justify them on the basis of scientific findings on the glare effect in the eye. If necessary, the photometric test and measurement procedures for luminaires should then be adapted accordingly.
- **Campaigns** such as the German #mehrAchtung initiative provide information to road users about what they can do to reduce glare in road traffic and how they can respond helpfully if they are dazzled.

## Tips for members and consumers

Road users can take their own measures to reduce glare in road traffic, such as:

- the deactivation of automatic or adaptive high beam systems in the event of insufficient function
- Correct adjustment of the headlamp levelling with a loaded vehicle
- Regularly checking the headlamp adjustment at a specialist vehicle workshop, in particular after repair work on the vehicle body
- Cleaning the headlight cover
- Timely switching off of the rear fog light when visibility improves
- using the parking brake when waiting for long periods at traffic lights
- the correct adjustment of bicycle lights

Clean lenses and visual aids help reduce glare. Regularly checking the eyesight allows specialists to recognise any deterioration at an early stage. Looking directly at the dazzling light source should be avoided; the **ADAC recommends looking at the road and objects in your own lane or at the right-hand edge of the lane.**

Prof. Dr. Helmut Wilhelm (University Eye Clinic Tübingen) was able to show that wearing tinted spectacle lenses, especially so-called **yellow filter lenses**, reduces the subjective feeling of glare, but the measured values show that twilight vision and sensitivity to glare are significantly worse. The wearer of tinted glasses may feel that they are subjectively less dazzled, but objectively their vision is significantly worse. Prof. Dr. Bernhard Lachenmayr, ophthalmologist, therefore advises against the use of such glasses, as they **endanger road safety** at dusk and at night.

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ADAC e.V.  
 Test and technology  
 81360 Munich  
 E-mail tet@adac.de  
 www.adac.de

## Attachment B

ANWB report of survey on glare on road traffic, summarised results AMZS, ANWB, Bihamk, IAM Roadsmart and NAF. Club members were invited to give their opinion, a high number of entries was the result. Same questionnaire as in Attachment "A".

# Glare in road traffic

Results of AMZS, ANWB, Bihamk, IAM Roadsmart and NAF

January 2024

## European consumer study on glare in road traffic

A collaboration between several European Automobilclubs:  
ACL, ADAC, AMZS, ANWB, BIHAMK, IAM, NAF, ÖAMTC, TCB and TCS

Results gathered by ANWB, Iris Welvaarts en Harm Zeven



# Contents

› Management Summary	03
› Study design	04
› Results	04
› Conclusion of the results	13

## Management Summary

- Drivers feel dazzled by street lighting and other drivers. It happens relatively rarely with street lighting – only 5% of drivers (almost) always feel dazzled by street lighting.
- Glare from other drivers occurs much more frequently. 50% are (almost) regularly dazzled, 49% at least sometimes. And although it happens so often, it is still annoying for drivers (69%).
- The high beam is the light source that most frequently dazzles other drivers, as do the low beam and rear fog light.
- If the drivers are dazzled, it is very difficult for them to see anything around the light source. They react irritated.
- This creates very dangerous situations for road traffic. Drivers react to glare by closing their eyes, looking away or blinking.
- As a result, drivers feel stressed or drive less.
- One-third (32%) feels more dazzled by large light sources. About 29% recognize no difference in glare due to the size of the light source.
- Drivers feel that regulations should be changed to improve the situation for them. 57% of drivers believe that glare from car lights should be regulated as a high priority.

## Study design

- A large group of members of the FIA worked together on research how car drivers in Europe experience glare in traffic. ADAC and ANWB set up a survey to distribute among their members, and other clubs have followed this example.
- Goal was to find out whether car drivers do experience any difficulties in glare while being on the road, in order to provide solutions towards the European Commission.
- Two methods have been used to collect the sample for the study. One where a representative sample has been collected and one where club members have been invited to participate the study.

## Two methods

- This report addresses the combined results of the survey of Norway, Slovenia and the Netherlands. These countries conducted the study among their member base and ANWB gathered the results.
- ADAC performed the same study for Germany, Belgium, Austria, Switzerland and Luxemburg. Per country they recruited a representative sample of inhabitants (N = 1000 per country). The results of this study are in line with the results shown in this report.

## British results

- The results of United Kingdom are not included because IAM did not ask exactly the same questions.
- Although, the conclusions of United Kingdom are in line with the general European results.
- In March 2022, a RAC survey of 2,700 drivers found also that 89 % think some or most car headlights on the UK's roads are too bright, with a majority of these (88 %) saying they get dazzled by them while driving.

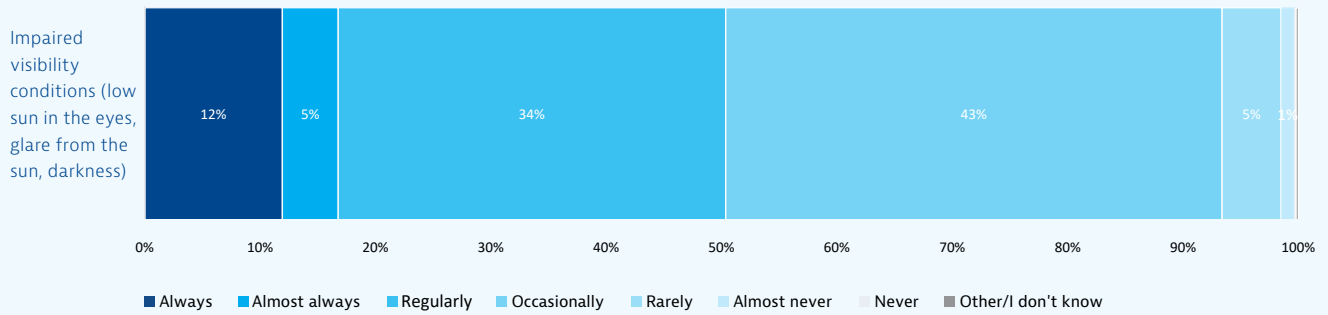
## Sample

- ANWB, AMZS and NAF recruited their respondents via their own member base. These are the sample sizes per organization/country:
  - The Netherlands (ANWB): 13.640
  - Slovenia (AMZS): 2.766
  - Norway (NAF): 1.108
  - Bosnia Herzegovina (BIHAMK): 181
- This report shows the average score of the Netherlands, Norway and Slovenia. Each country contributes equally to the average score. The results of Bosnia Herzegovina are not included in the average score due to the lower sample size here. This would be influencing the average too much. Although the conclusions are in line with the general European results, a report is available upon request.

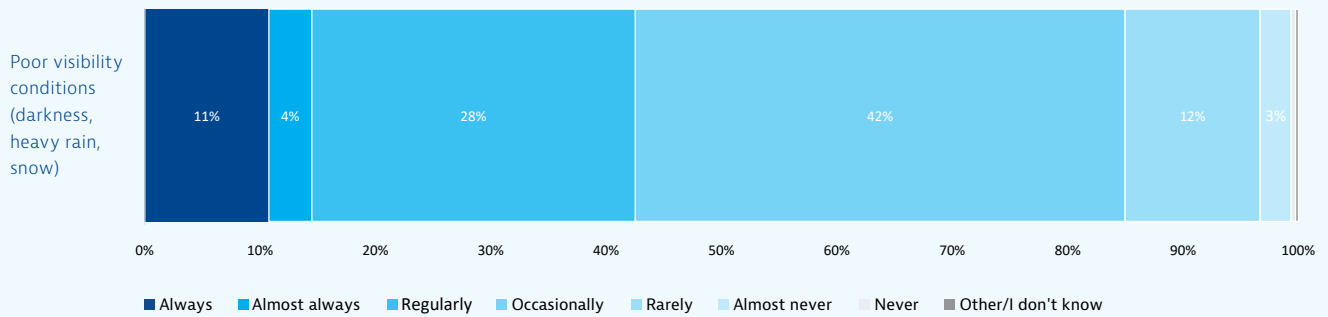
## Results

- Questionnaire has been executed in the period September–December 2023.
- Members have been approached by club magazines, internet pages of these automobile clubs and via social media.

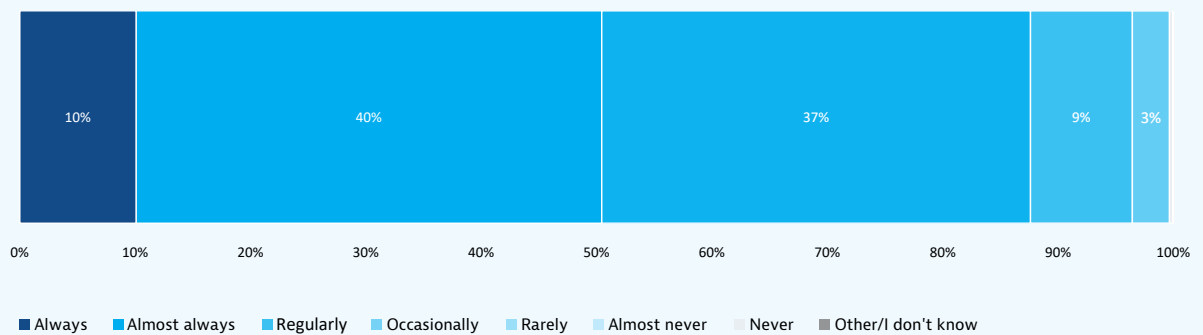
### In what visibility conditions have you driven in the last year? Impaired visibility conditions (low sun in the eyes, glare from the sun, darkness)



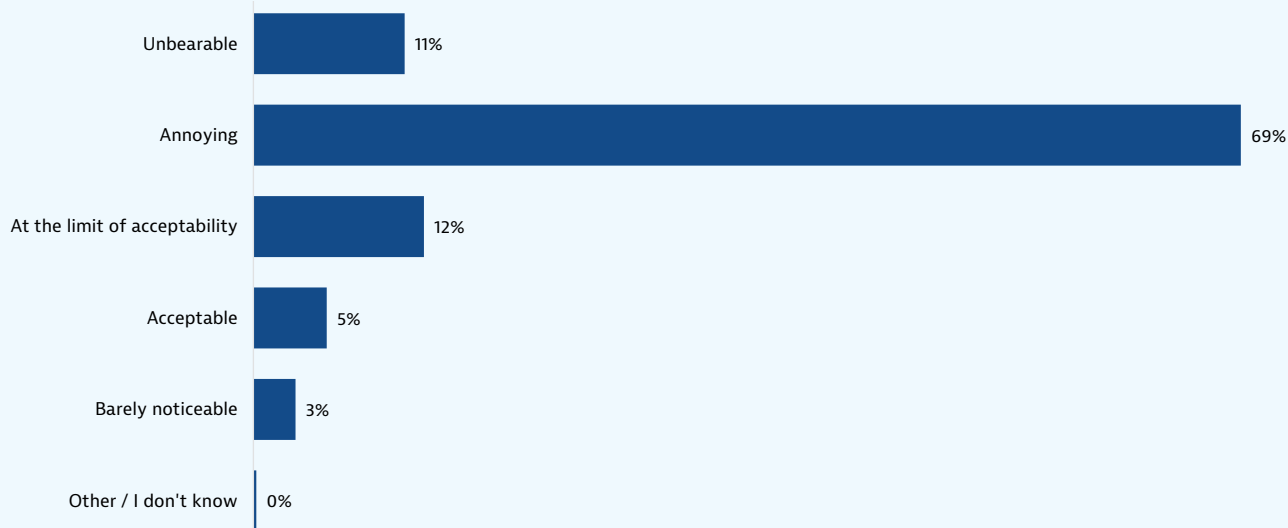
### In what visibility conditions have you driven in the last year? Poor visibility conditions (darkness, fog, heavy rain, snow)



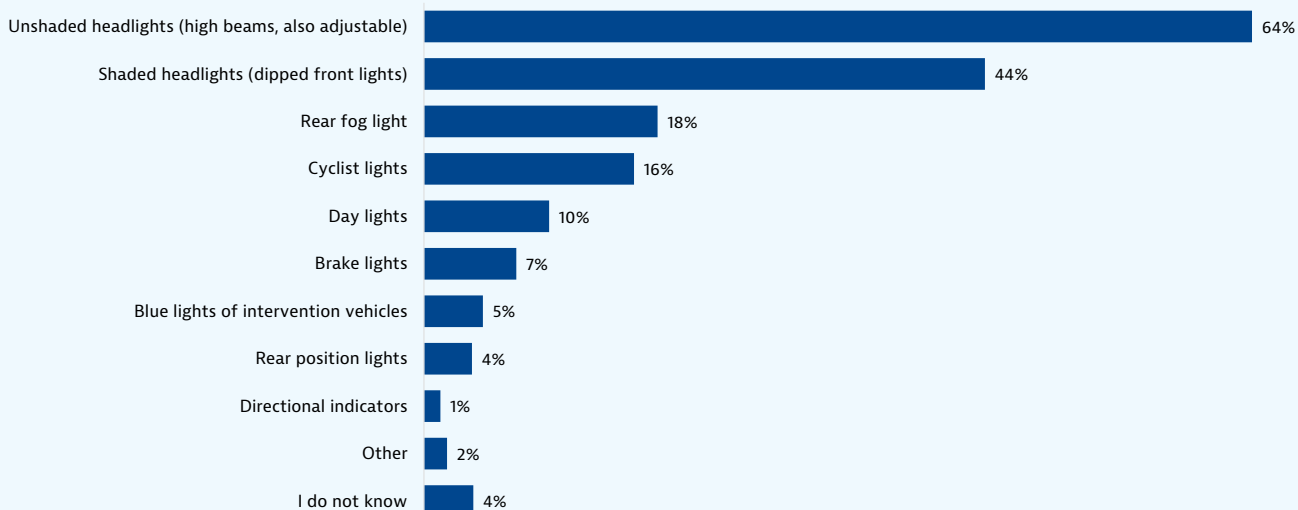
### Do you ever get blinded by the light from other vehicles?



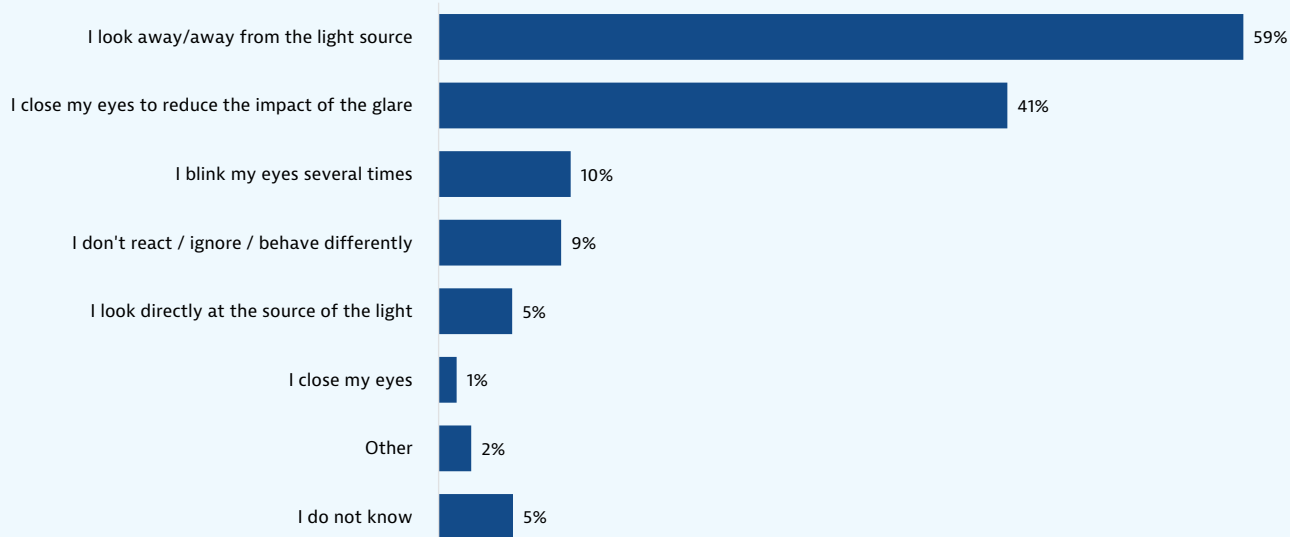
## How do you experience being dazzled by the light of other vehicles?



## What light sources from other vehicles blind you while driving?

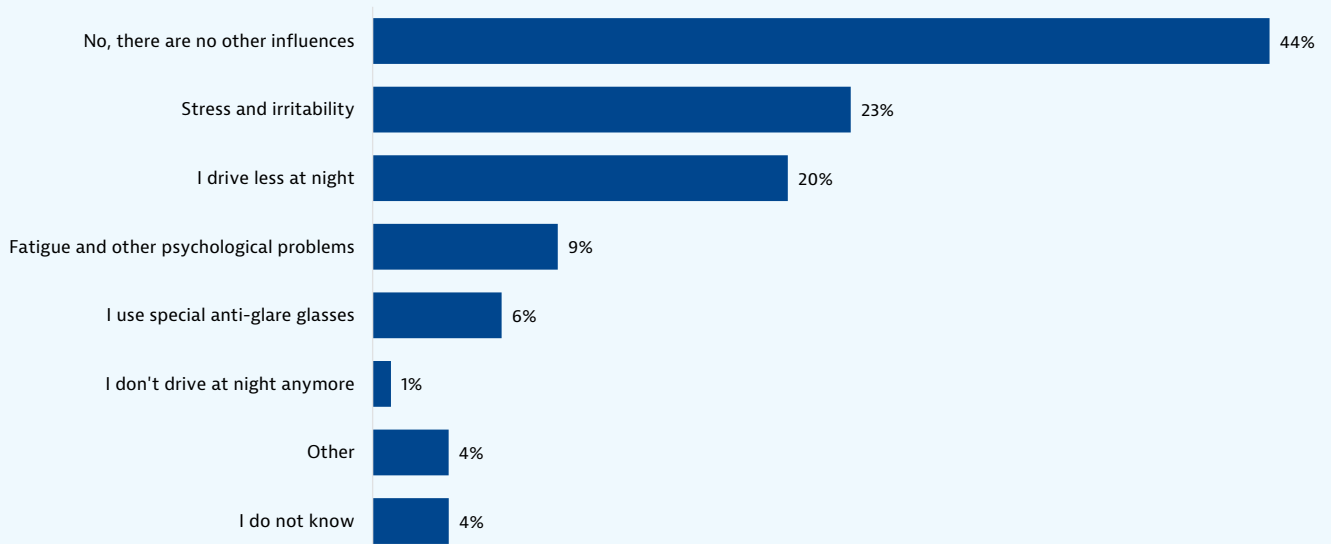


## What do you do when faced with blinding light?

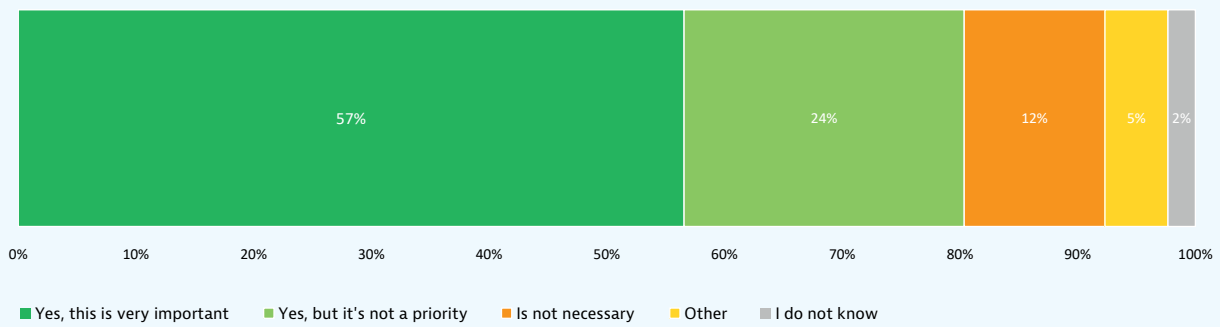




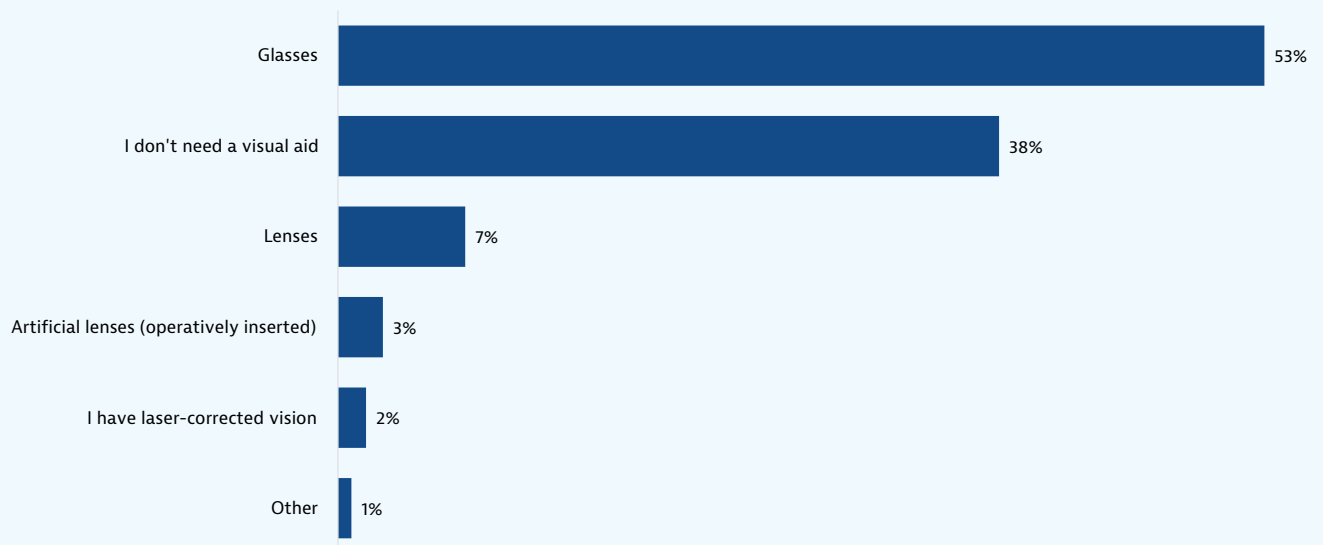
### Does the glare have any other effect on you?



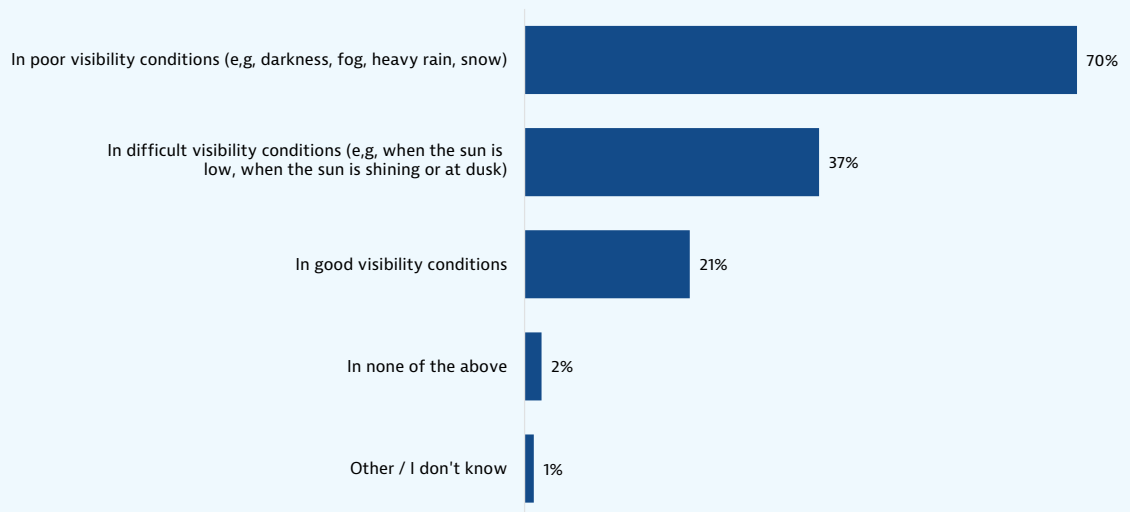
### Do you think there is a need to review and update regulations to reduce glare caused by vehicle light sources?



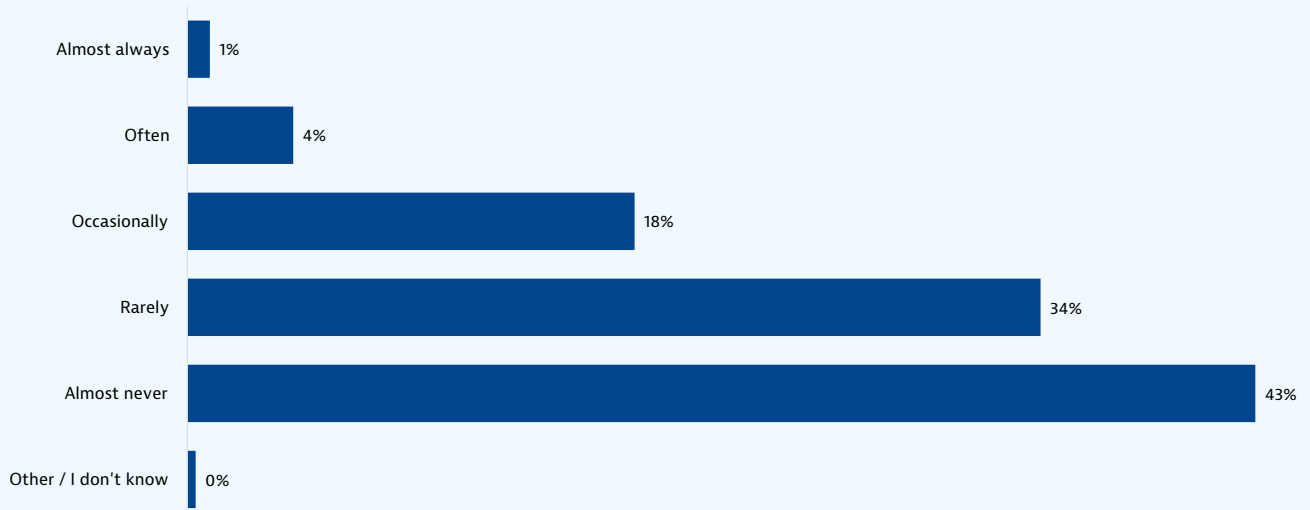
### Do you need vision assistance when driving?



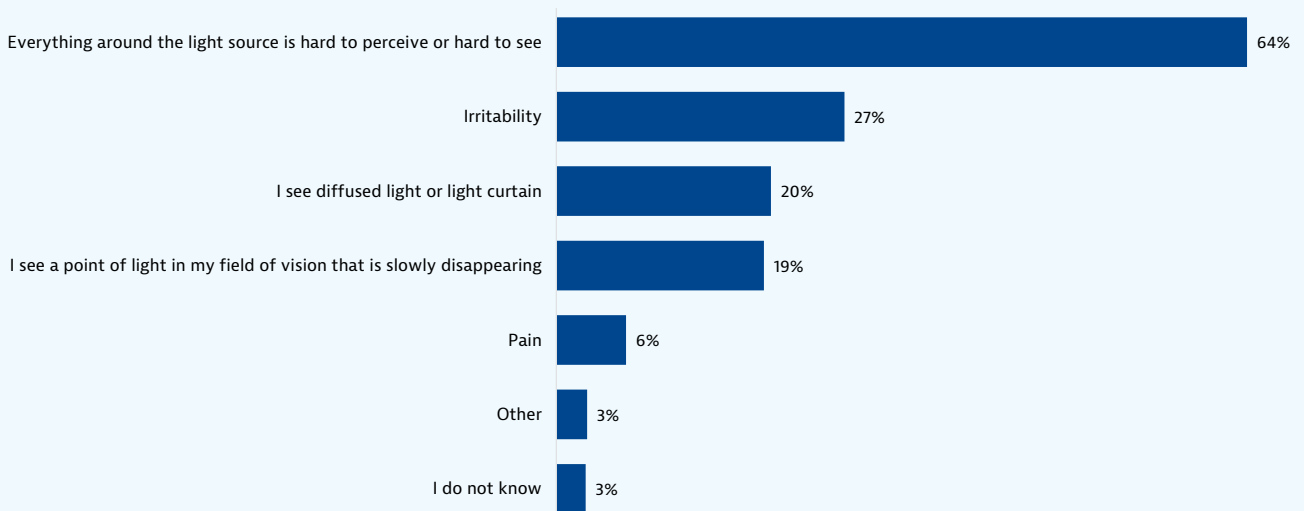
## In what visibility conditions have you been blinded by the light of other vehicles?



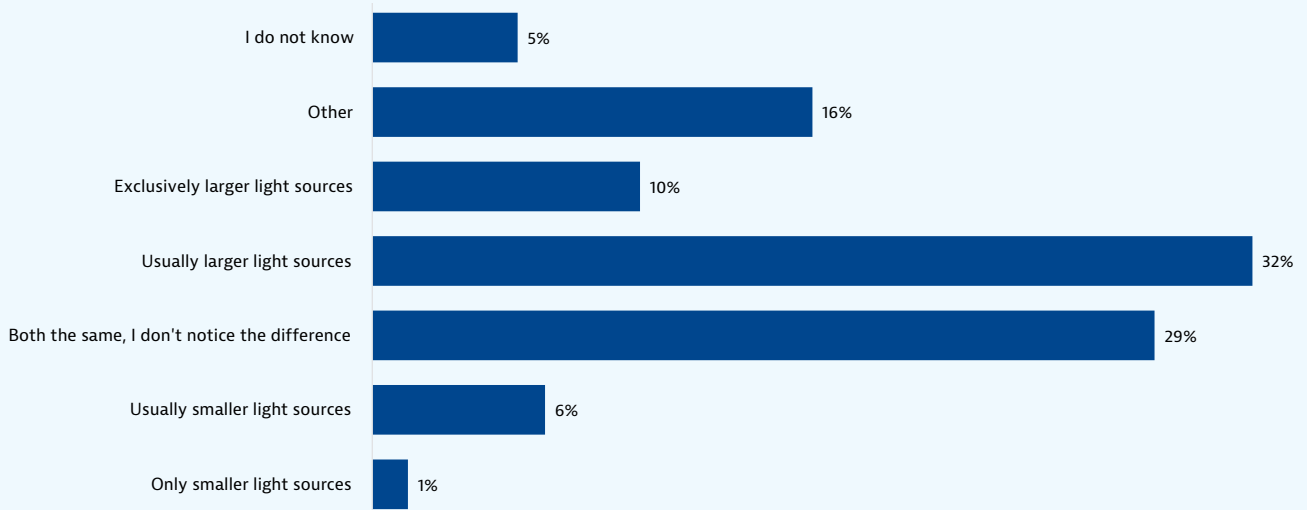
## Have you ever been blinded by road lights or other roadside light sources?



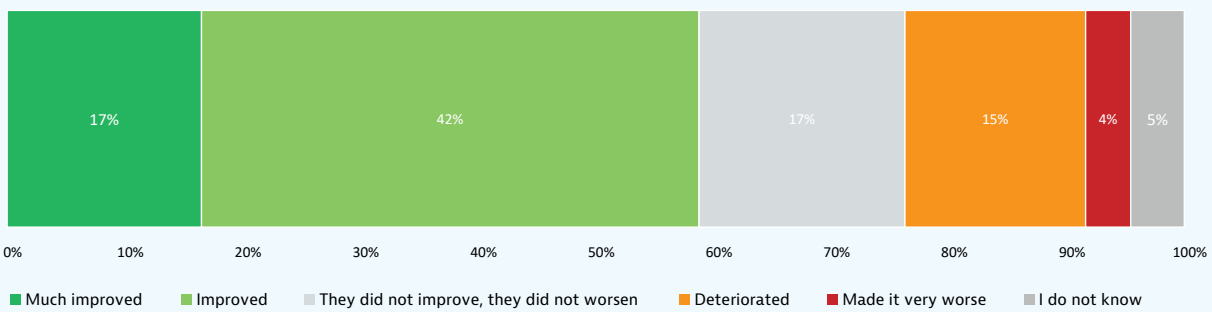
## How does being blinded by lights affect you?



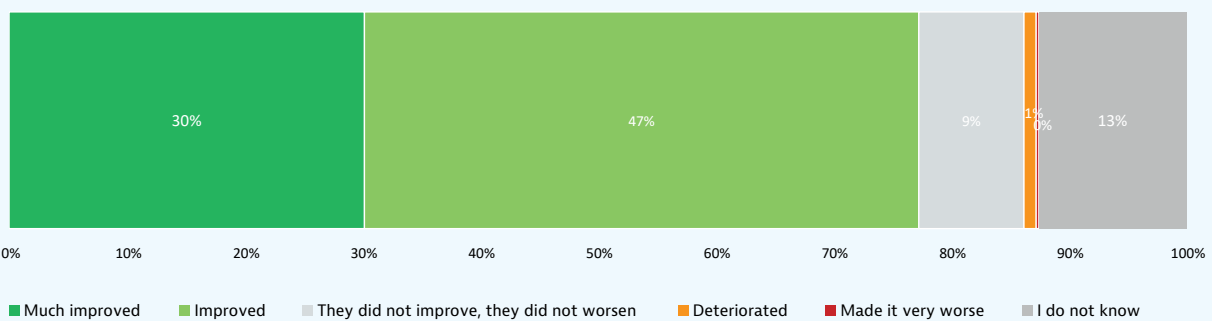
**If you imagine that the design or size of the light source is related to the perception of glare, which type of light source causes you more glare?**



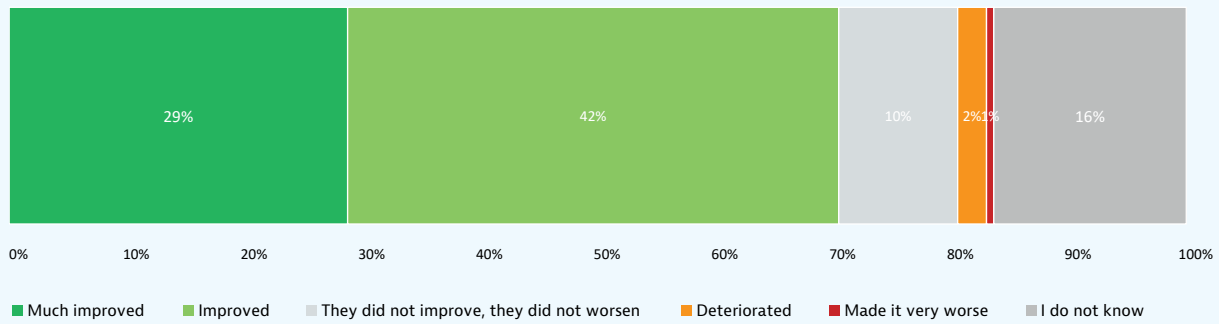
**In your opinion, have the following safety systems improved road safety in the last 10, 15 years?  
Car lights (unshaded, shaded, indicators)**



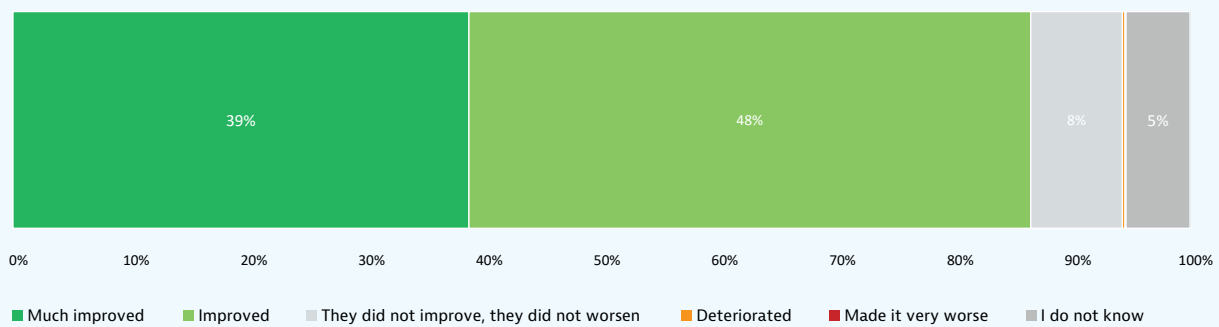
**In your opinion, have the following safety systems improved road safety in the last 10, 15 years?  
Passive safety systems (vehicle safety cage, controlled deformations in the event of a collision, ...)**



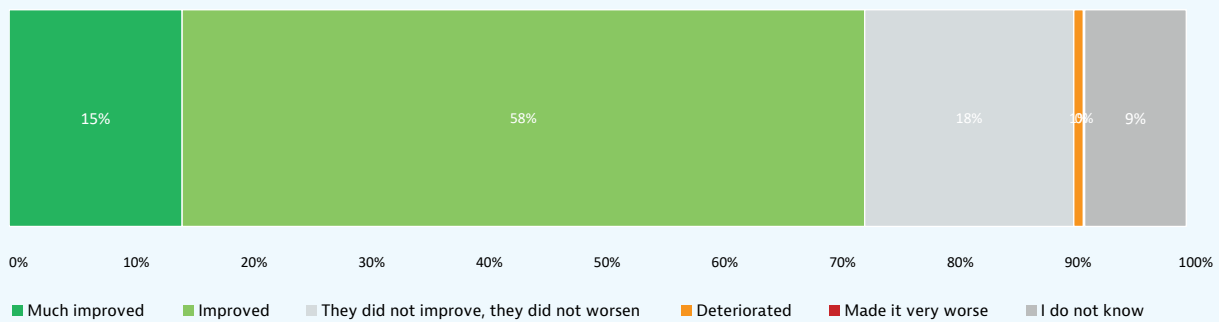
**In your opinion, have the safety systems below improved road safety in the last 10, 15 years?  
Advanced assistance systems (emergency braking system, lane departure warning system, fatigue detection system, ...**



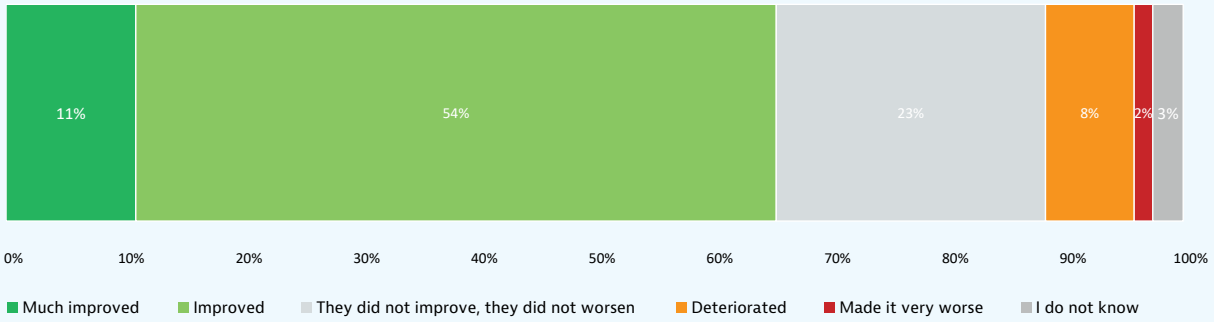
**In your opinion, have the following safety systems improved road safety in the last 10, 15 years?  
Restraint systems (safety belts, seat belts, child safety seats) fatigue detection, ...**



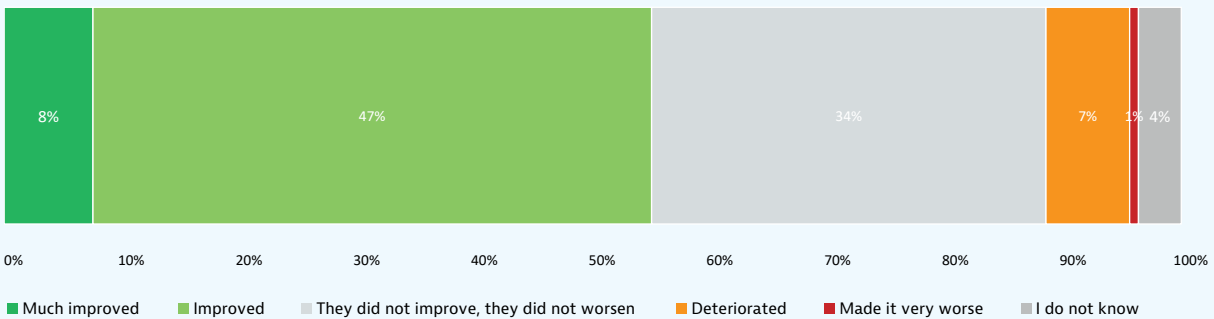
**In your opinion, have the following safety systems improved road safety in the last 10, 15 years?  
Car tires (profile, proper pressure, use of winter and summer tires)**



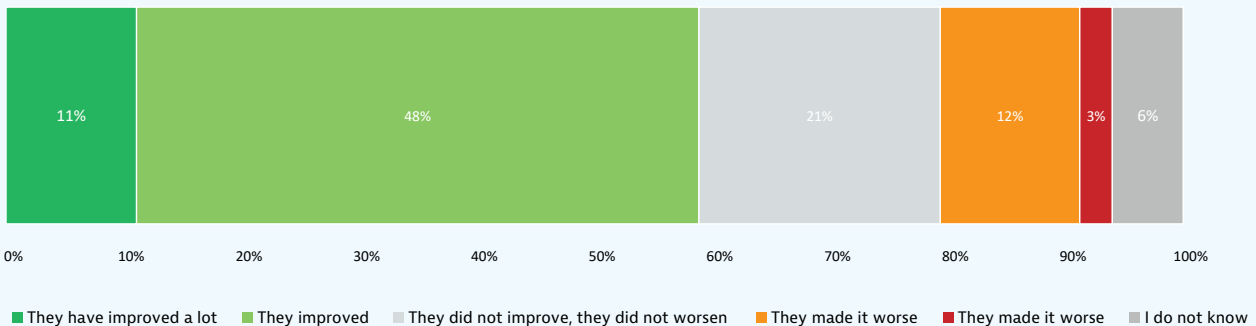
**In your opinion, have the following safety systems improved road safety in the last 10, 15 years?  
Transport infrastructure (cycling areas, roundabouts, slow lanes, ...)**



**In your opinion, have the following safety systems improved road safety in the last 10, 15 years?  
Road lighting**

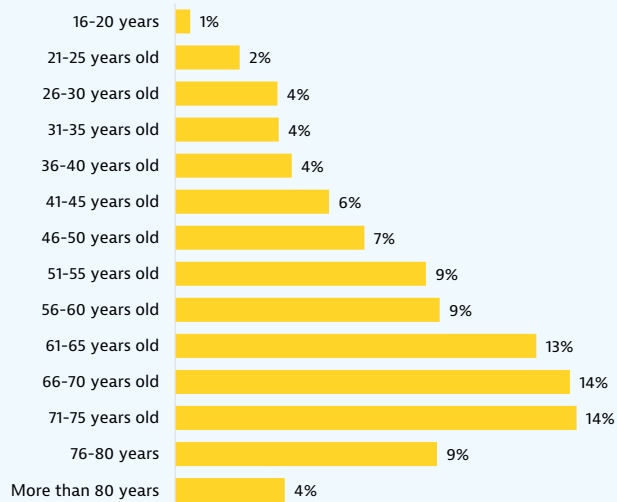


**Do you think that in the last 10, 15 years, automotive lighting systems have improved visibility at night?**

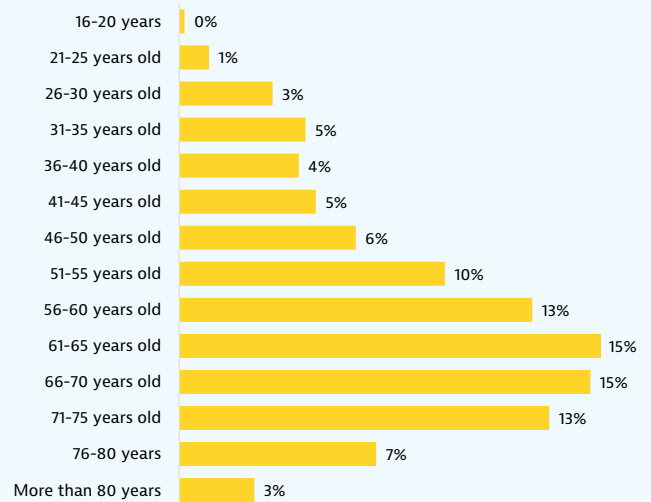


## Sample background

Age of the total sample



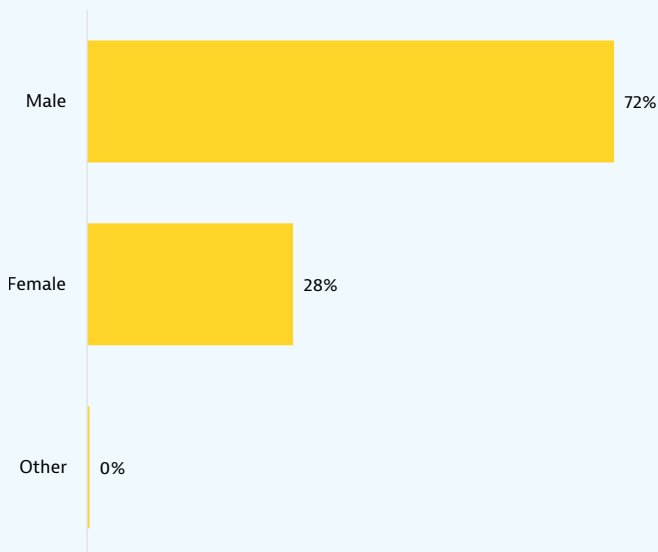
Age of Dutch population



Older age group members respond more often, but still 25% of participants in NL is < 51 years

## Sample background

Gender of the total sample



Men tend to participate more often in the member survey

## Conclusion of these results

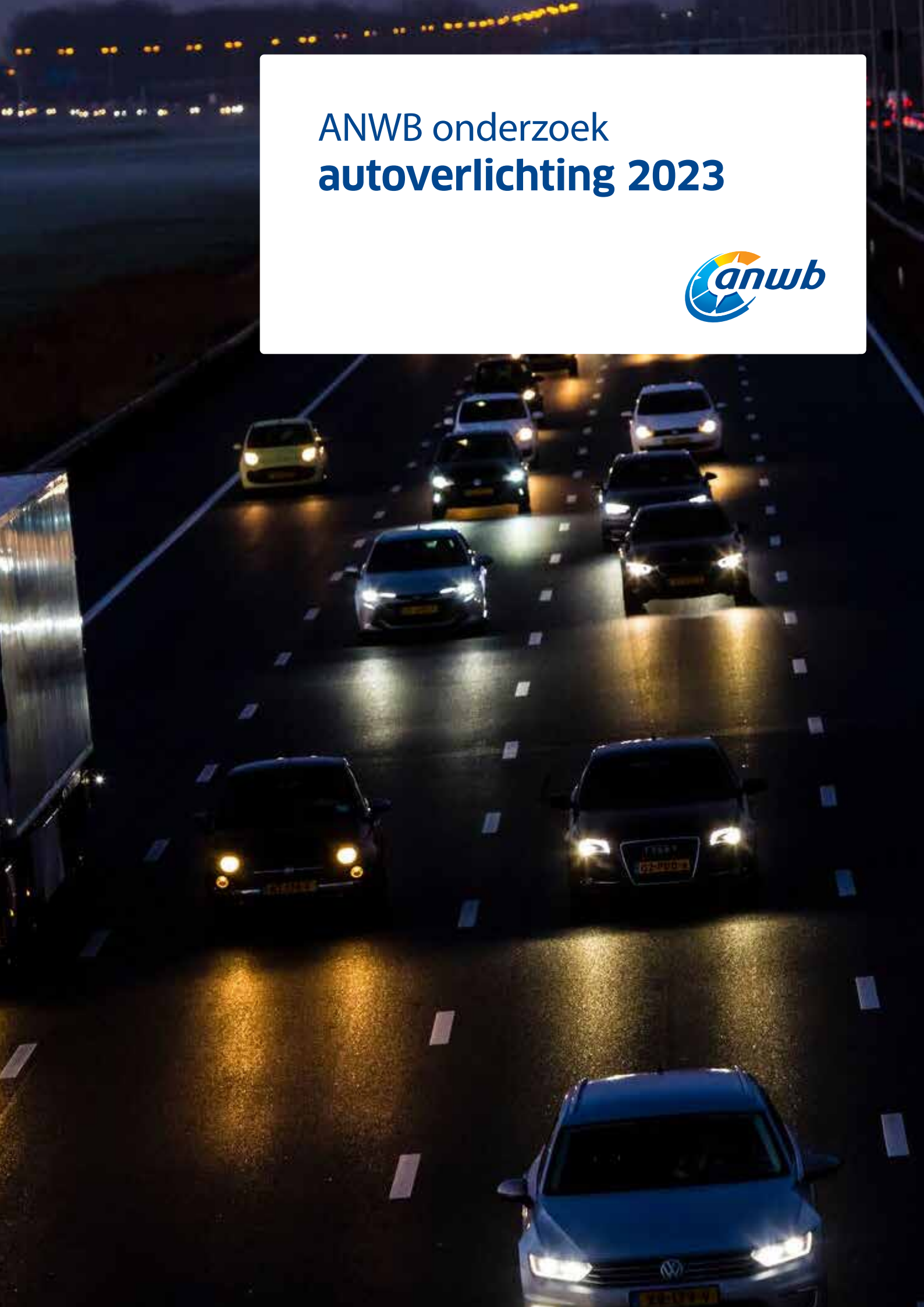
- Glare lighting seems to be quite an issue, since 88% of the people addresses to experience this on a regular base. The majority would classify this as annoying or even unbearable.
- Although the sample collection is different from the research method conducted by ADAC, the results are quite similar.
- Age does not play an important factor in the results; youngsters seem to experience the same discomfort as elderly people.

## Attachment C

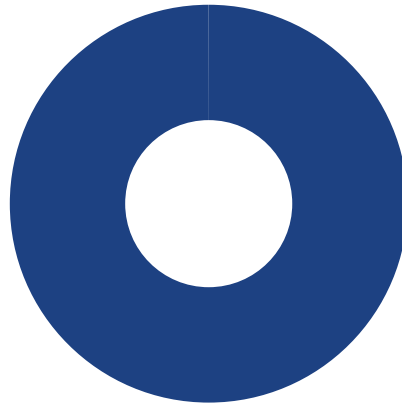
ANWB results of the survey vehicle lighting 2023. Answers given by the 13.640 respondents who gave in October-November 2023 their opinion on modern vehicle lighting. Canals used were ANWB club's magazine "Kampioen" and social media. Same questionnaire as in Attachment "A".



# ANWB onderzoek autoverlichting 2023



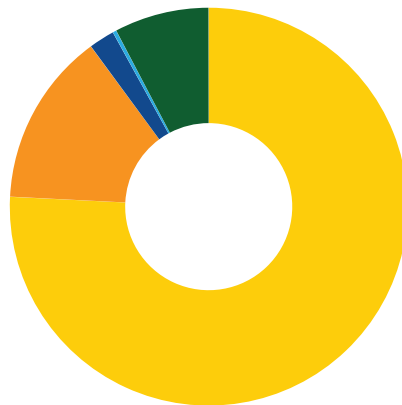
## Reactiestatus



Aantal respondenten

<b>Totaal</b>	<b>13,640</b>
● Niet geantwoord	0.0%
● Geweigerd	0.0%
● Incompleteet	0.0%
● Compleet	100.0%

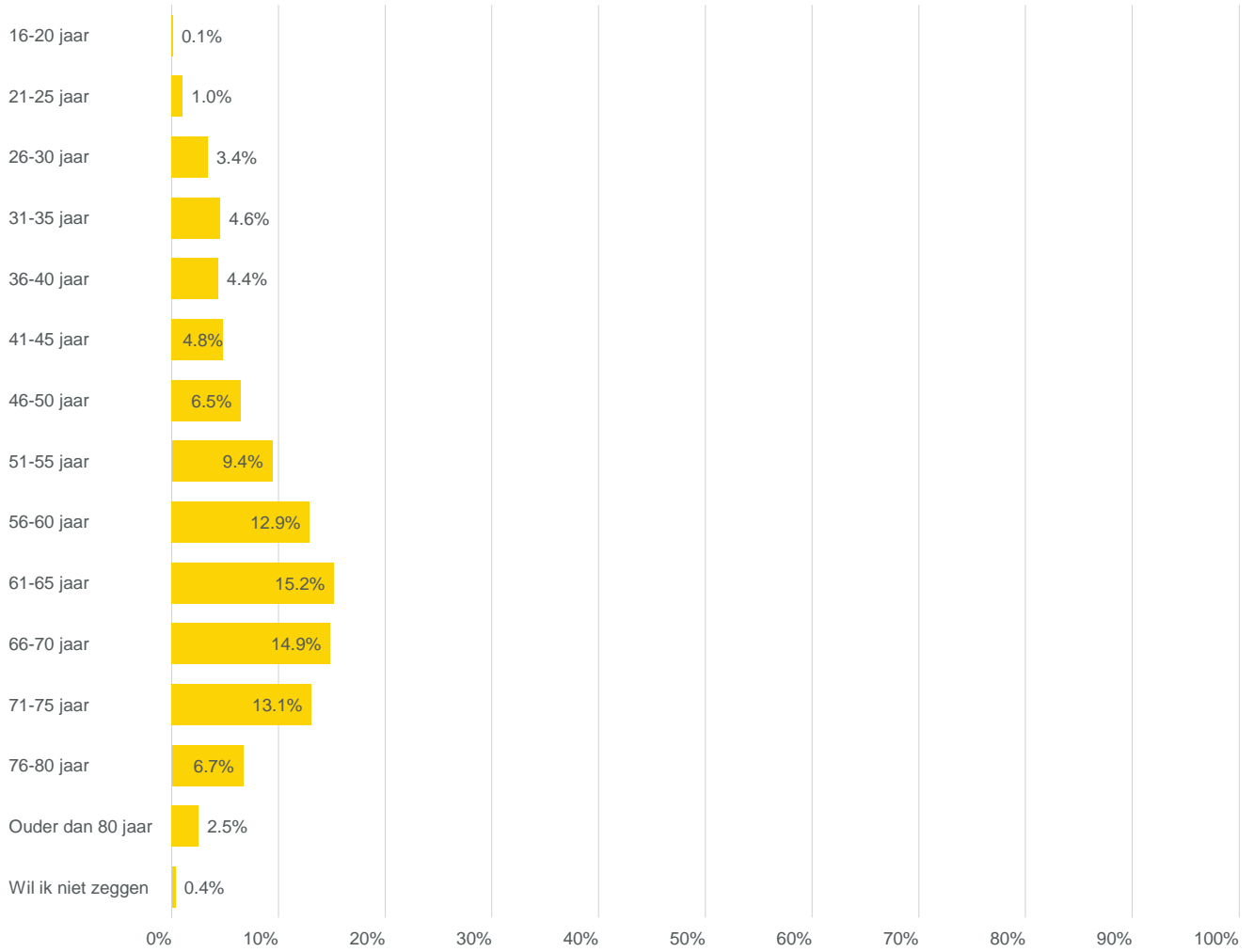
## Hoe bent u in deze vragenlijst terecht gekomen?



Aantal respondenten

<b>Totaal</b>	<b>13,640</b>
● Via een linkje in de Kampioen	75.8%
● Via een linkje op anwb.nl	14.1%
● Via een uitnodiging van het ANWB Ledenpanel	2.1%
● Via X / Twitter	0.3%
● Anders, namelijk ...	7.7%

### Wat is uw leeftijd?

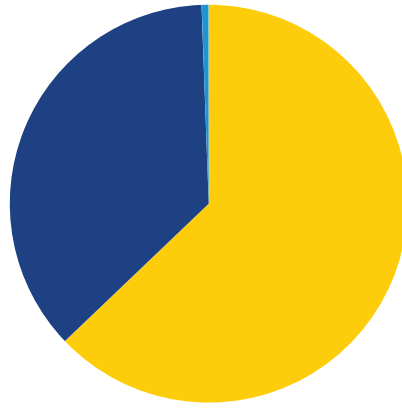


Aantal respondenten

**Totaal**

**13,640**

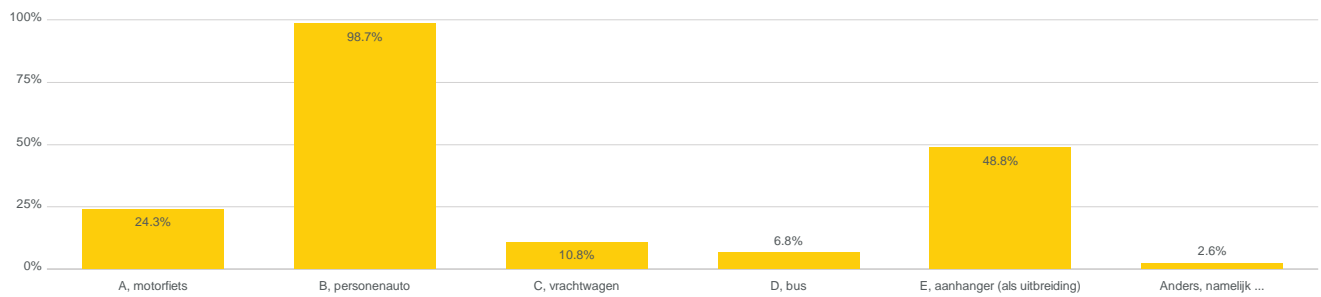
## Wat is uw geslacht?



Aantal respondenten

Totaal	Aantal
Man	62.9%
Vrouw	36.6%
Anders, namelijk ...	0.6%

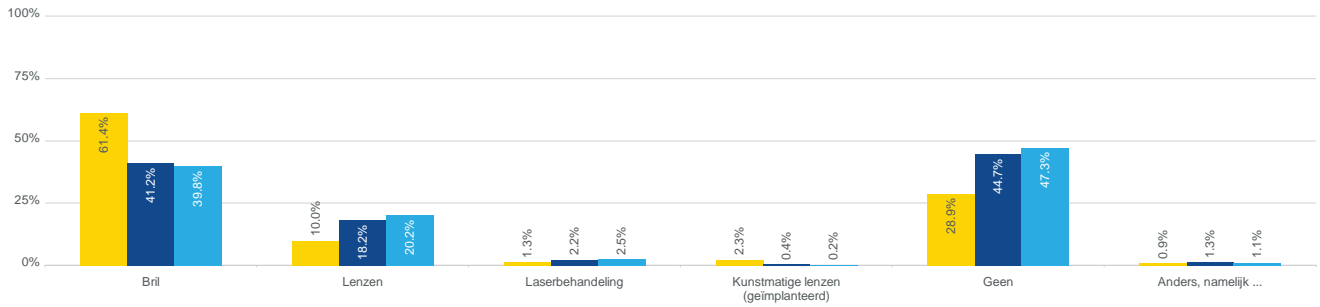
## Welk rijbewijs heeft u? (meerdere antwoorden mogelijk)



Aantal respondenten

Totaal	Aantal
Totaal	13,640

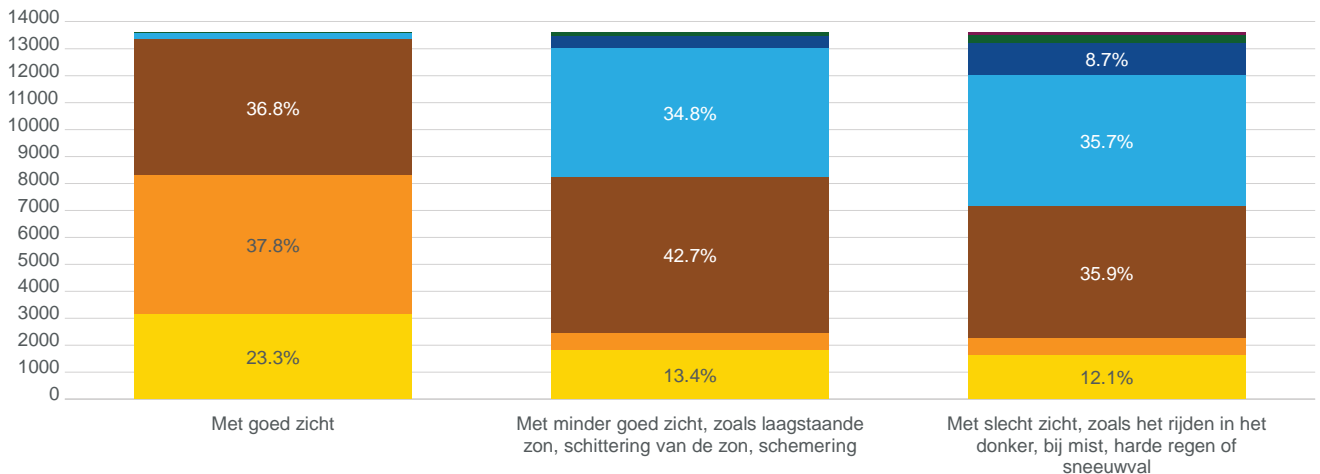
### Heeft of gebruikt u een visueel hulpmiddel als u rijdt? (meerdere antwoorden mogelijk)



Aantal respondenten

● Totaal	13,640
● Leeftijd (t/m 50 jaar)	3,382
● Leeftijd (Jongeren, t/m 35 jaar)	1,241

### Onder welke zichtomstandigheden heeft u de afgelopen 12 maanden gereden?

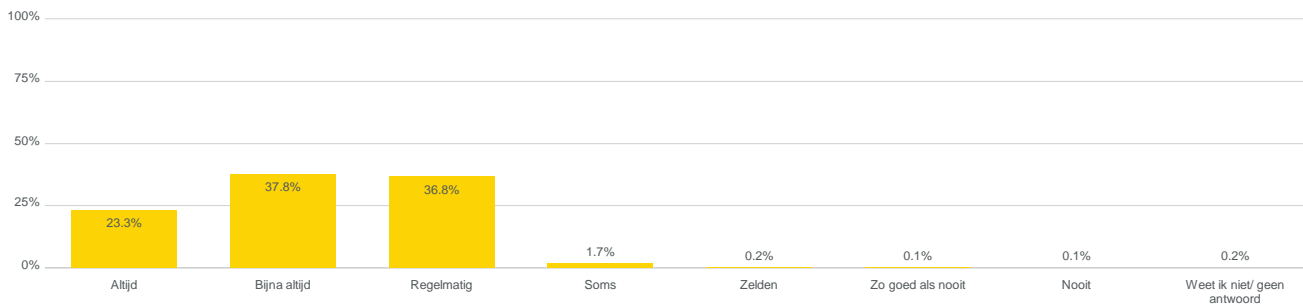


Aantal respondenten

<b>Totaal</b>	<b>13,640</b>
● Altijd	
● Bijna altijd	
● Regelmatig	
● Soms	
● Zelden	
● Zo goed als nooit	
● Nooit	
● Weet ik niet/ geen antwoord	

### Onder welke zichtomstandigheden heeft u de afgelopen 12 maanden gereden?

Met goed zicht



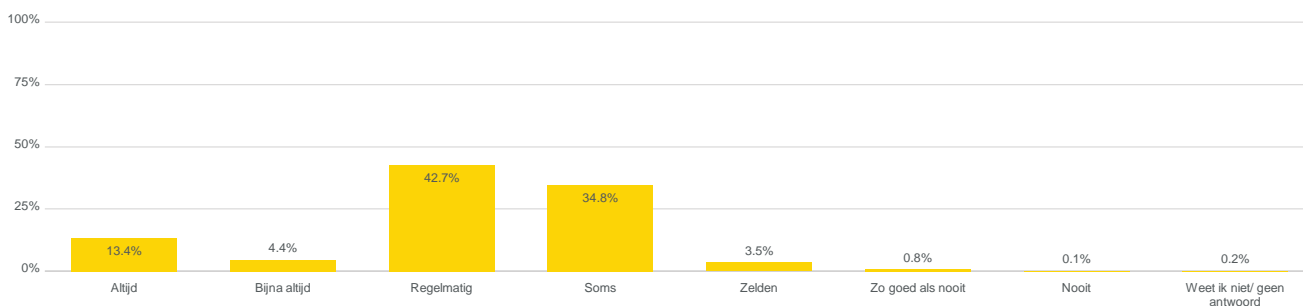
Aantal respondenten

**Totaal**

**13,640**

### Onder welke zichtomstandigheden heeft u de afgelopen 12 maanden gereden?

Met minder goed zicht, zoals laagstaande zon, schittering van de zon, schemering



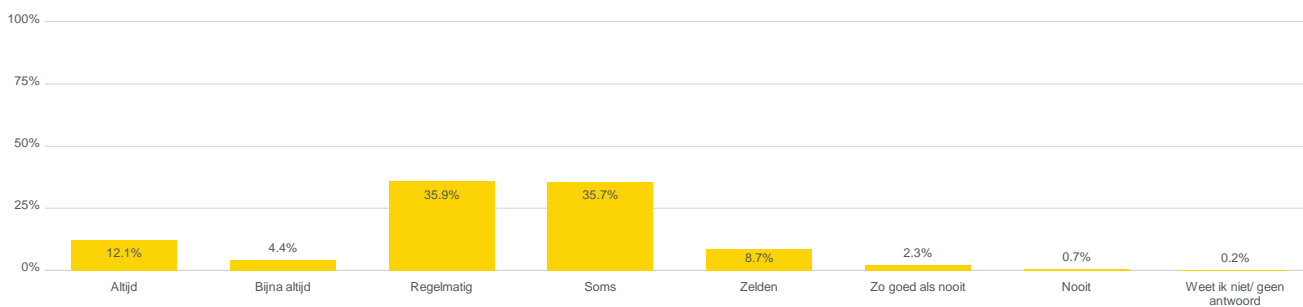
Aantal respondenten

**Totaal**

**13,640**

### Onder welke zichtomstandigheden heeft u de afgelopen 12 maanden gereden?

Met slecht zicht, zoals het rijden in het donker, bij mist, harde regen of sneeuwval

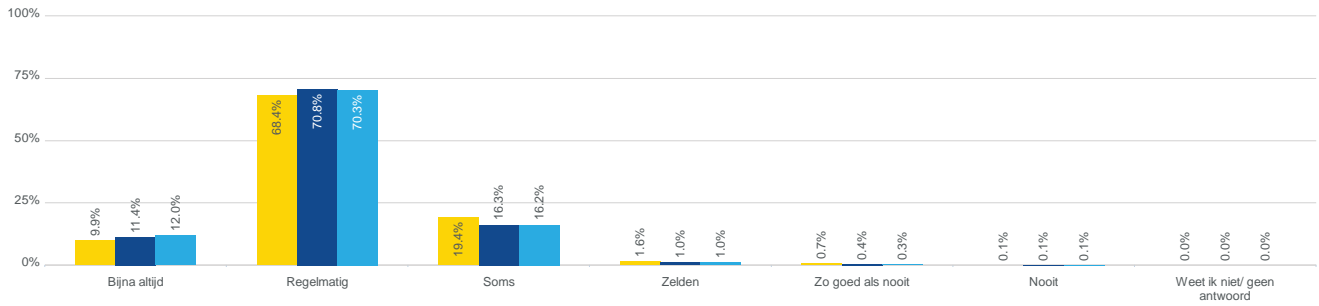


Aantal respondenten

**Totaal**

**13,640**

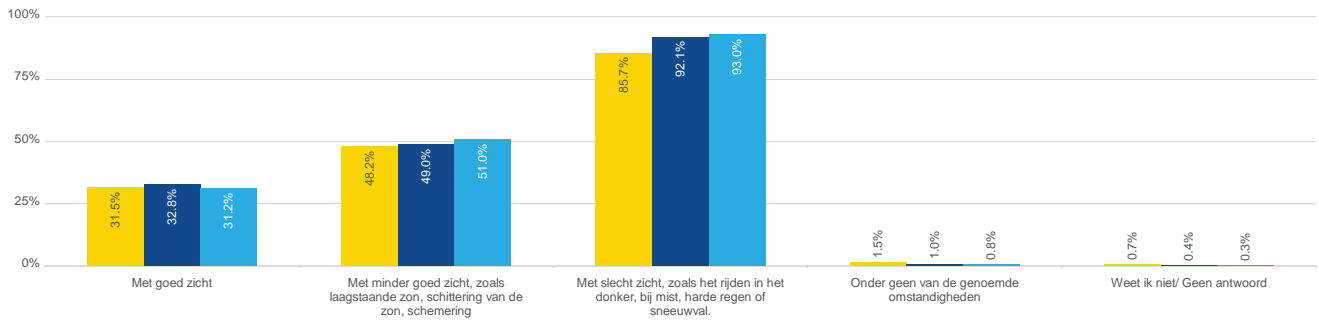
### Wordt u wel eens verblind door andere voertuigen (of weggebruikers)?



Aantal respondenten

● Totaal	13,640
● Leeftijd (t/m 50 jaar)	3,382
● Leeftijd (Jongeren, t/m 35 jaar)	1,241

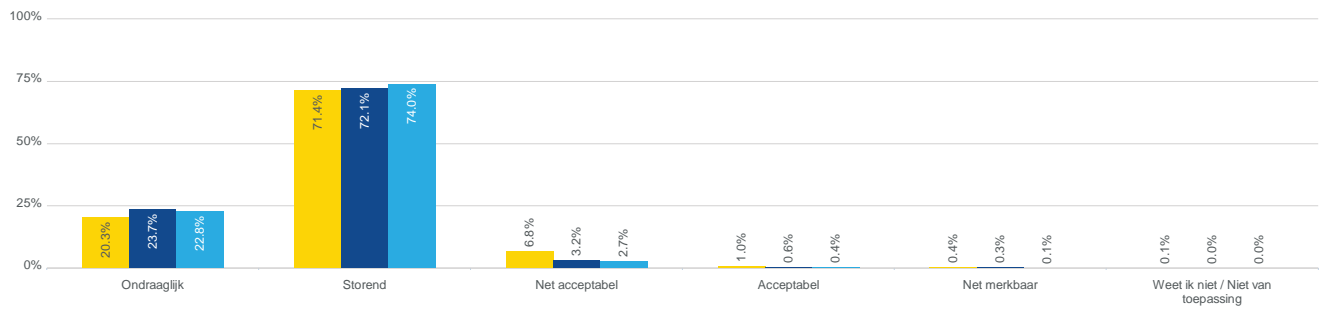
### Onder welke zichtomstandigheden voelt u zich verblind? (meerdere antwoorden mogelijk)



Aantal respondenten

● Totaal	13,632
● Leeftijd (t/m 50 jaar)	3,378
● Leeftijd (Jongeren, t/m 35 jaar)	1,240

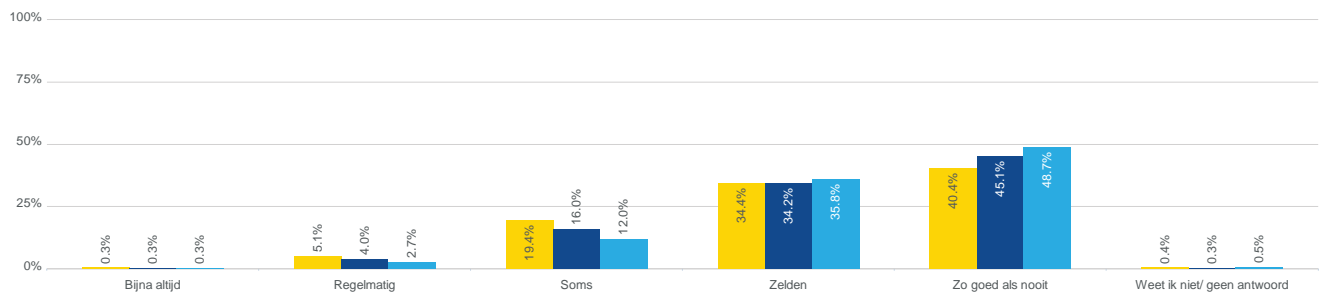
### Hoe ervaart u verblinding door andere voertuigen (of weggebruikers)?



Aantal respondenten

● Totaal	<b>13,632</b>
● Leeftijd (t/m 50 jaar)	<b>3,378</b>
● Leeftijd (Jongeren, t/m 35 jaar)	<b>1,240</b>

### Wordt u ooit verblind door straatverlichting en andere lichtbronnen?

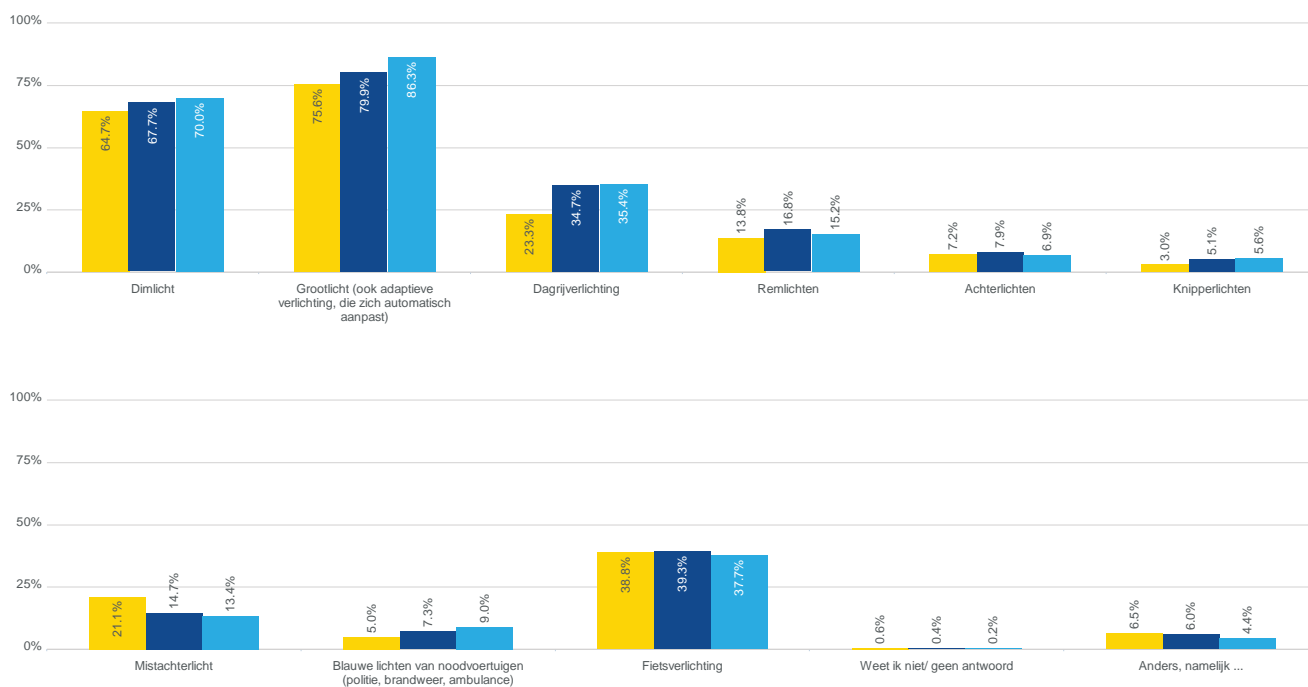


Aantal respondenten

● Totaal	<b>13,639</b>
● Leeftijd (t/m 50 jaar)	<b>3,381</b>
● Leeftijd (Jongeren, t/m 35 jaar)	<b>1,240</b>



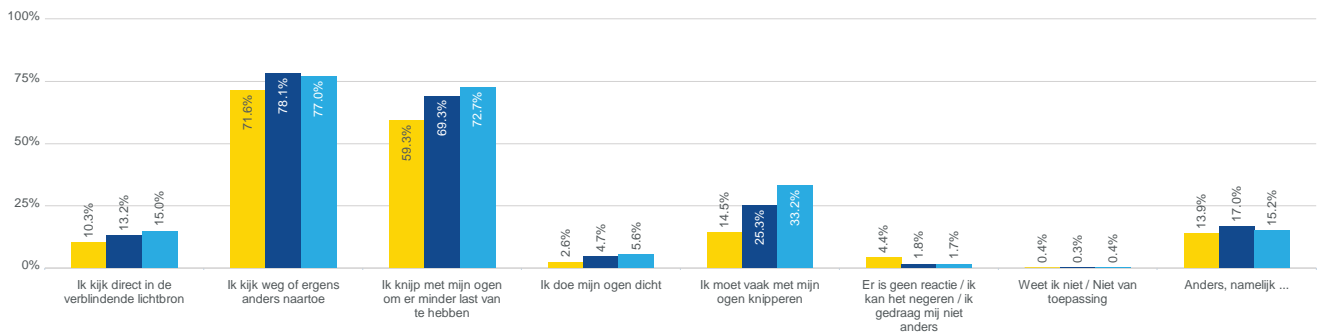
## Welke afzonderlijke lichtbronnen van andere voertuigen (of weggebruikers) verblinden u tijdens het rijden? (meerdere antwoorden mogelijk)



Aantal respondenten

● Totaal	13,632
● Leeftijd (t/m 50 jaar)	3,378
● Leeftijd (Jongeren, t/m 35 jaar)	1,240

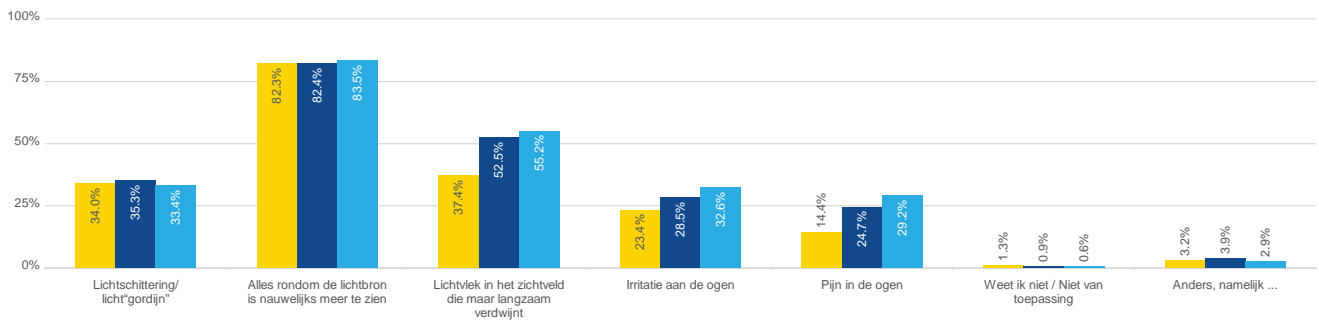
### Als u verblind wordt, hoe reageert u dan? (meerdere antwoorden mogelijk)



Aantal respondenten

● Totaal	<b>13,640</b>
● Leeftijd (t/m 50 jaar)	<b>3,382</b>
● Leeftijd (Jongeren, t/m 35 jaar)	<b>1,241</b>

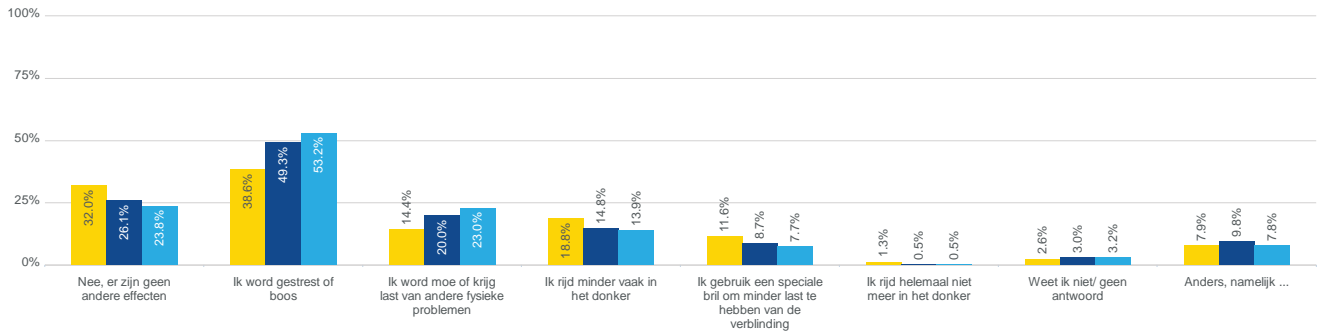
### Kunt u het effect beschrijven als u wordt verblind? (meerdere antwoorden mogelijk)



Aantal respondenten

● Totaal	<b>13,640</b>
● Leeftijd (t/m 50 jaar)	<b>3,382</b>
● Leeftijd (Jongeren, t/m 35 jaar)	<b>1,241</b>

## Heeft verblinding door verlichting nog andere effecten op u? (meerdere antwoorden mogelijk)

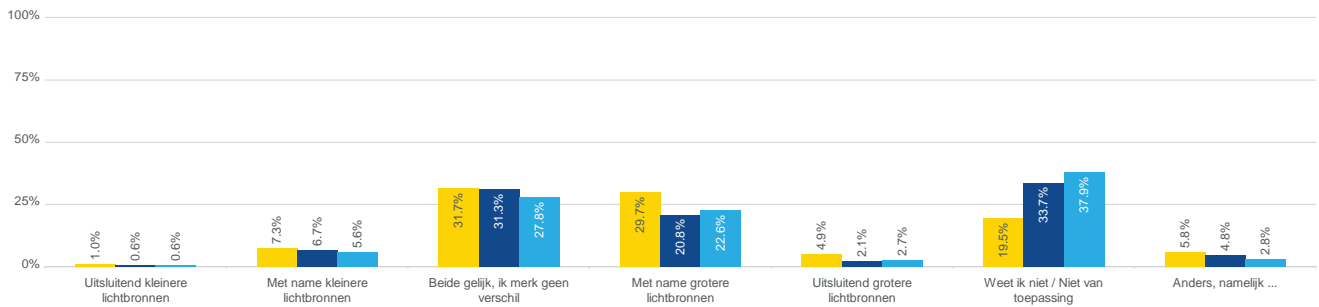


Aantal respondenten

● Totaal	<b>13,640</b>
● Leeftijd (t/m 50 jaar)	<b>3,382</b>
● Leeftijd (Jongeren, t/m 35 jaar)	<b>1,241</b>

## Wist u dat het ontwerp van de lichtbron uitmaakt voor de beleving van de verblinding?

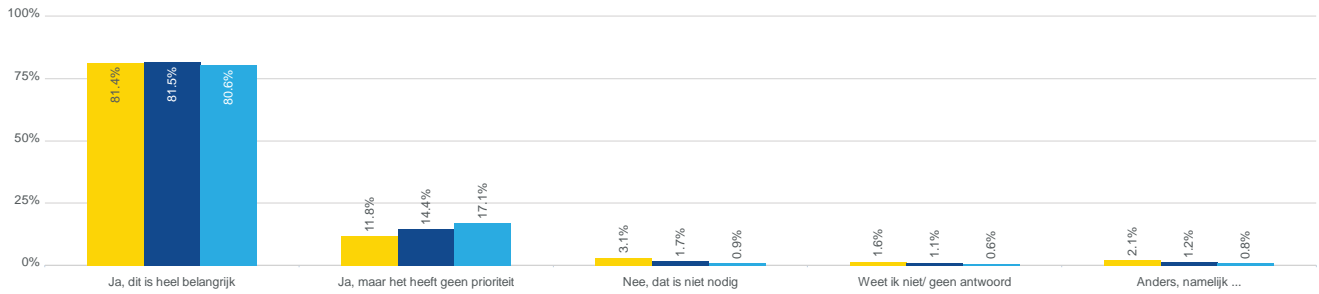
### Door welke soort wordt u het meeste verblind?



Aantal respondenten

● Totaal	<b>13,640</b>
● Leeftijd (t/m 50 jaar)	<b>3,382</b>
● Leeftijd (Jongeren, t/m 35 jaar)	<b>1,241</b>

## Vindt u het nodig dat de regelgeving moet worden herzien en aangepast om verblinding door voertuigverlichting te verminderen?

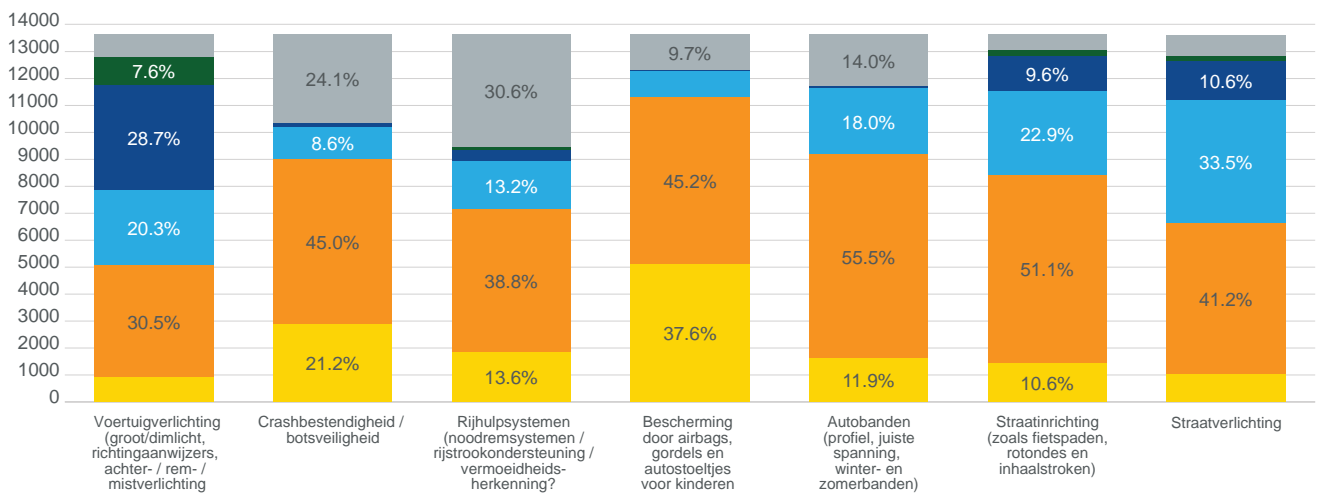


Aantal respondenten

● Totaal	13,640
● Leeftijd (t/m 50 jaar)	3,382
● Leeftijd (Jongeren, t/m 35 jaar)	1,241

## We zouden graag uw mening weten over een aantal veiligheidssystemen en hoe belangrijk u deze vindt.

### In hoeverre hebben deze de verkeersveiligheid de afgelopen 10 tot 15 jaar verbeterd?



Aantal respondenten

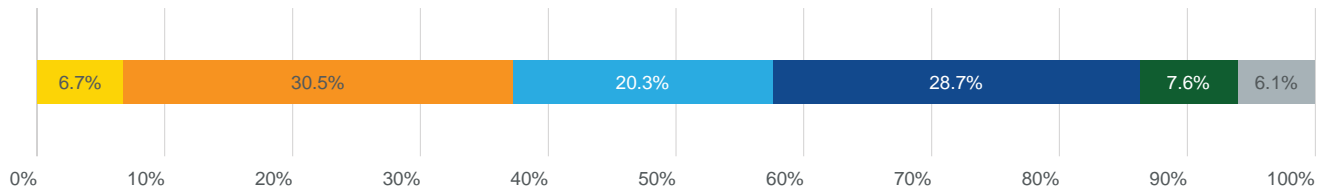
● Totaal	13,640
----------	--------

- Heel erg verbeterd
- Verbeterd
- Niet verbeterd, niet verslechterd
- Verslechterd
- Heel erg verslechterd
- Weet ik niet/ geen antwoord

**We zouden graag uw mening weten over een aantal veiligheidssystemen en hoe belangrijk u deze vindt.**

**In hoeverre hebben deze de verkeersveiligheid de afgelopen 10 tot 15 jaar verbeterd?**

Voertuigverlichting (groot/dimlicht, richtingaanwijzers, achter- / rem- / mistverlichting)



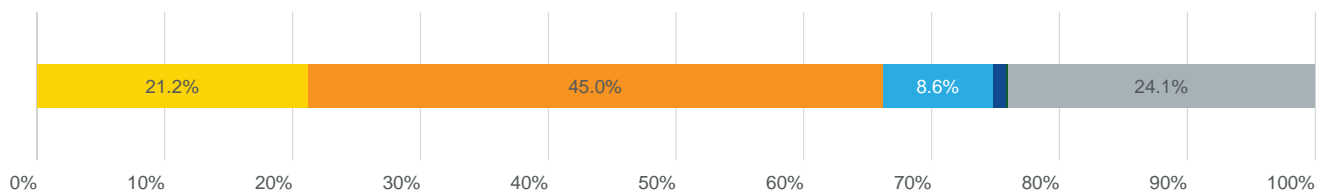
Aantal respondenten

<b>Totaal</b>	<b>13,640</b>
● Heel erg verbeterd	6.7%
● Verbeterd	30.5%
● Niet verbeterd, niet verslechterd	20.3%
● Verslechterd	28.7%
● Heel erg verslechterd	7.6%
● Weet ik niet/ geen antwoord	6.1%

**We zouden graag uw mening weten over een aantal veiligheidssystemen en hoe belangrijk u deze vindt.**

**In hoeverre hebben deze de verkeersveiligheid de afgelopen 10 tot 15 jaar verbeterd?**

Crashbestendigheid / Botsveiligheid



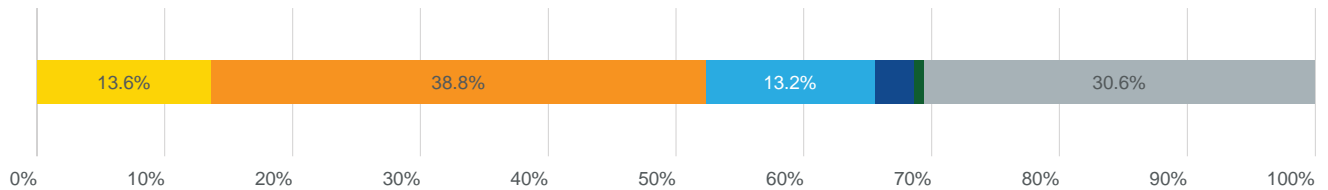
Aantal respondenten

<b>Totaal</b>	<b>13,640</b>
● Heel erg verbeterd	21.2%
● Verbeterd	45.0%
● Niet verbeterd, niet verslechterd	8.6%
● Verslechterd	1.0%
● Heel erg verslechterd	0.2%
● Weet ik niet/ geen antwoord	24.1%

## We zouden graag uw mening weten over een aantal veiligheidssystemen en hoe belangrijk u deze vindt.

### In hoeverre hebben deze de verkeersveiligheid de afgelopen 10 tot 15 jaar verbeterd?

Rijhulpsystemen (noodremsystemen / rijstrookondersteuning / vermoeidheidsherkenning)



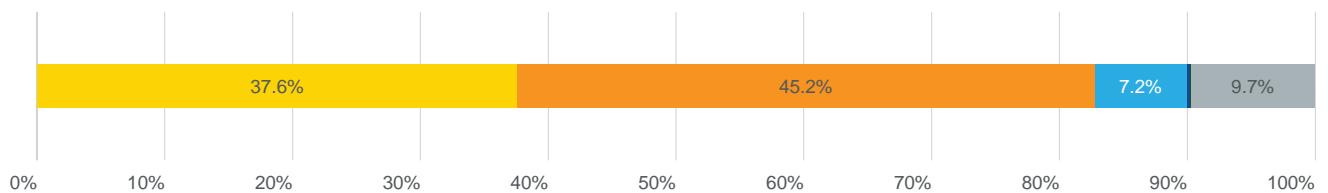
Aantal respondenten

Totaal	Aantal
Heel erg verbeterd	13.6%
Verbeterd	38.8%
Niet verbeterd, niet verslechterd	13.2%
Verslechterd	3.1%
Heel erg verslechterd	0.7%
Weet ik niet/ geen antwoord	30.6%

## We zouden graag uw mening weten over een aantal veiligheidssystemen en hoe belangrijk u deze vindt.

### In hoeverre hebben deze de verkeersveiligheid de afgelopen 10 tot 15 jaar verbeterd?

Bescherming door airbags, gordels en autostoeltjes voor kinderen



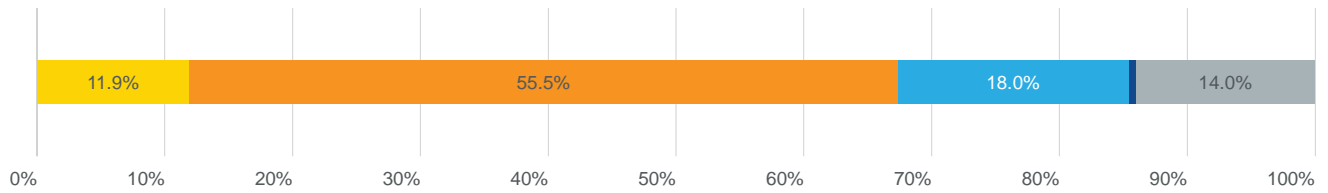
Aantal respondenten

Totaal	Aantal
Heel erg verbeterd	37.6%
Verbeterd	45.2%
Niet verbeterd, niet verslechterd	7.2%
Verslechterd	0.2%
Heel erg verslechterd	0.1%
Weet ik niet/ geen antwoord	9.7%

We zouden graag uw mening weten over een aantal veiligheidssystemen en hoe belangrijk u deze vindt.

### In hoeverre hebben deze de verkeersveiligheid de afgelopen 10 tot 15 jaar verbeterd?

Autobanden (profiel, juiste spanning, winter- en zomerbanden)



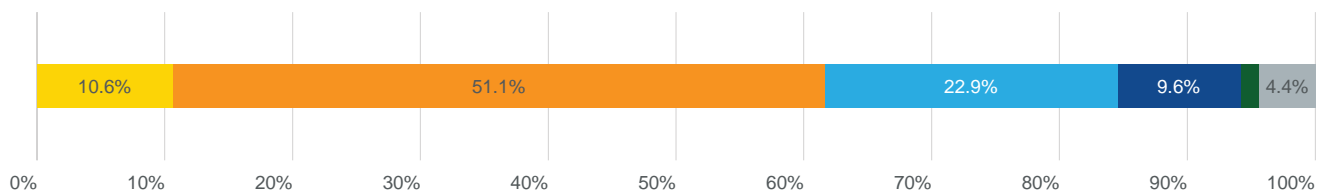
Aantal respondenten

Totaal	Aantal
Heel erg verbeterd	11.9%
Verbeterd	55.5%
Niet verbeterd, niet verslechterd	18.0%
Verslechterd	0.5%
Heel erg verslechterd	0.1%
Weet ik niet/ geen antwoord	14.0%

We zouden graag uw mening weten over een aantal veiligheidssystemen en hoe belangrijk u deze vindt.

### In hoeverre hebben deze de verkeersveiligheid de afgelopen 10 tot 15 jaar verbeterd?

Straatinrichting (zoals fietspaden, rotondes en inhaalstroken)



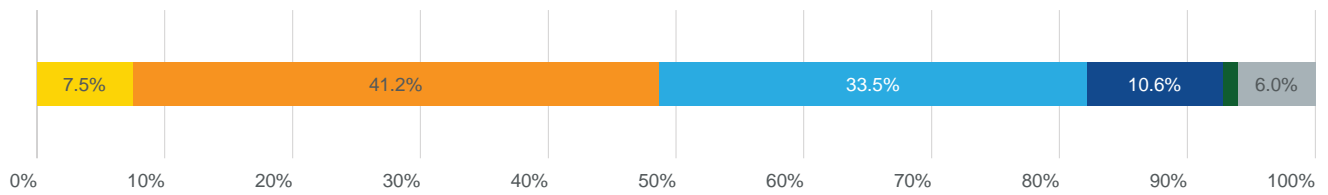
Aantal respondenten

Totaal	Aantal
Heel erg verbeterd	10.6%
Verbeterd	51.1%
Niet verbeterd, niet verslechterd	22.9%
Verslechterd	9.6%
Heel erg verslechterd	1.5%
Weet ik niet/ geen antwoord	4.4%

## We zouden graag uw mening weten over een aantal veiligheidssystemen en hoe belangrijk u deze vindt.

### In hoeverre hebben deze de verkeersveiligheid de afgelopen 10 tot 15 jaar verbeterd?

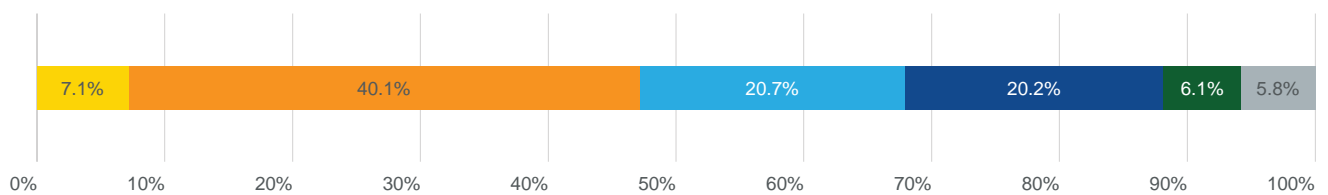
Straatverlichting



Aantal respondenten

Totaal	Aantal
Heel erg verbeterd	7.5%
Verbeterd	41.2%
Niet verbeterd, niet verslechterd	33.5%
Verslechterd	10.6%
Heel erg verslechterd	1.2%
Weet ik niet/ geen antwoord	6.0%

### Vindt u dat autoverlichting het zicht op de weg in de nacht heeft verbeterd of verslechterd, in de afgelopen 10 tot 15 jaar?

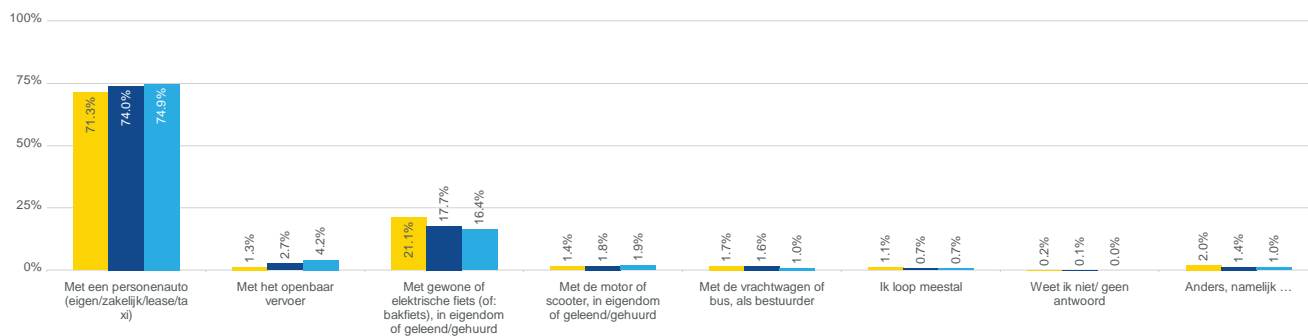


Aantal respondenten

Totaal	Aantal
Heel erg verbeterd	7.1%
Verbeterd	40.1%
Niet verbeterd, niet verslechterd	20.7%
Verslechterd	20.2%
Heel erg verslechterd	6.1%
Weet ik niet/ geen antwoord	5.8%



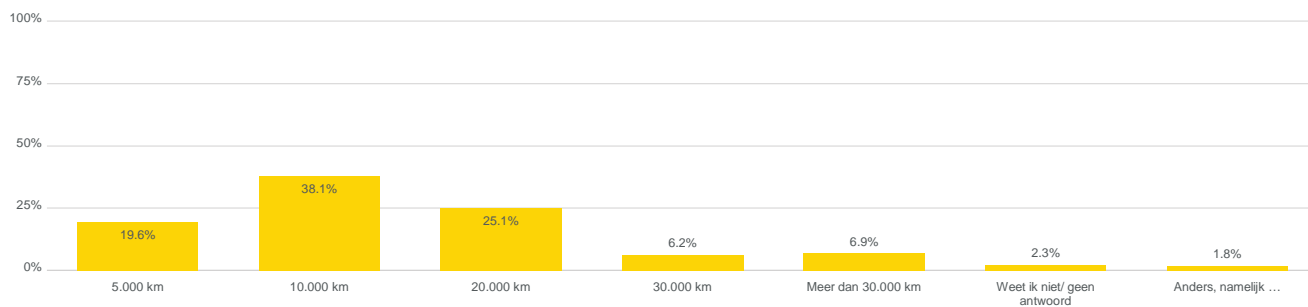
## Hoe verplaatst u zich normaal gesproken? (Kies het vervoersmiddel dat u het meest gebruikt)



### Observaties

● Totaal	13,640
● Leeftijd (t/m 50 jaar)	3,382
● Leeftijd (Jongeren, t/m 35 jaar)	1,241

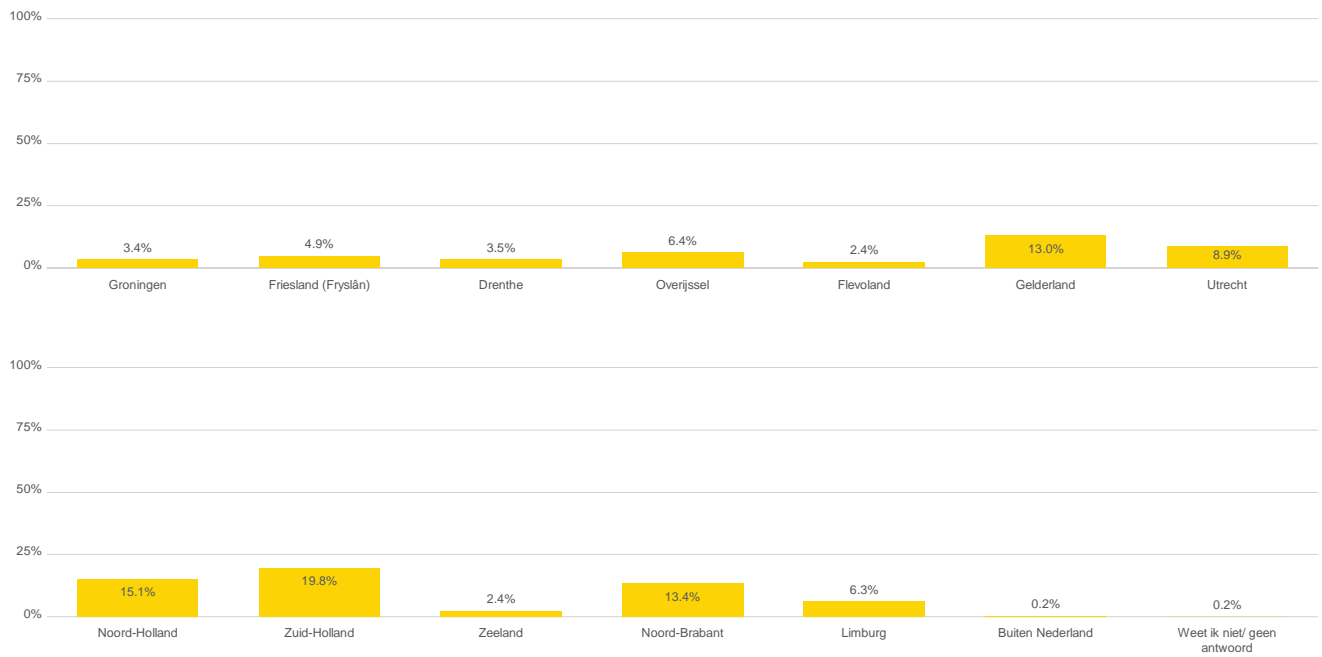
## Hoeveel kilometers heeft u de laatste twaalf maanden zelf een voertuig bestuurd? (Kies het antwoord dat het dichtst bij uw aantal kilometers in de buurt ligt)



### Observaties

<b>Totaal</b>	<b>13,640</b>
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## In welke provincie woont u?

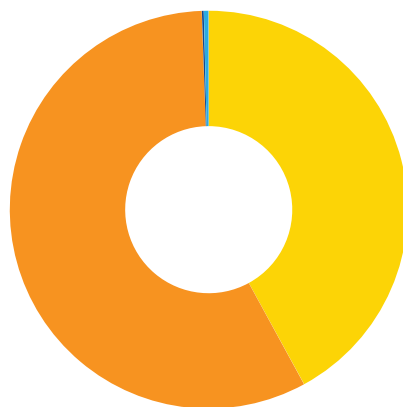


Aantal respondenten

**Totaal**

**13,640**

## Beschrijf het gebied waar u woont



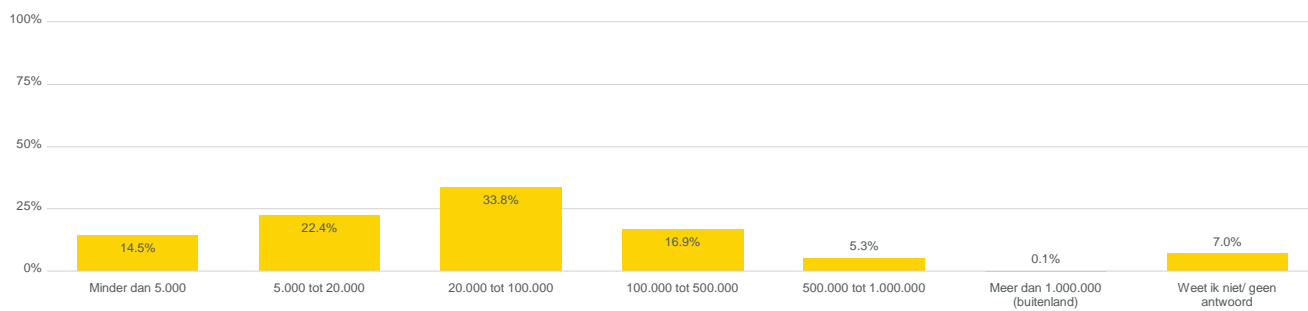
Aantal respondenten

**Totaal**

**13,640**

Op het platteland of in een dorp	42.0%
In een stad of stadje	57.4%
In een metropool (alleen als u in het buitenland woont, bv London)	0.2%
Weet ik niet/ geen antwoord	0.4%

## Hoeveel inwoners heeft uw woonplaats?



Aantal respondenten

**Totaal**

**13,640**



## Attachment D

RAC report of survey on glare on road traffic: When it comes to the effects of glare on drivers, two-in-three (67%) who suffer say they have to slow down considerably until they can see clearly again, while a similar proportion (64%) believe some headlights are so bright they risk causing accidents. In fact, five per cent of these drivers state they have nearly been involved in a collision themselves.

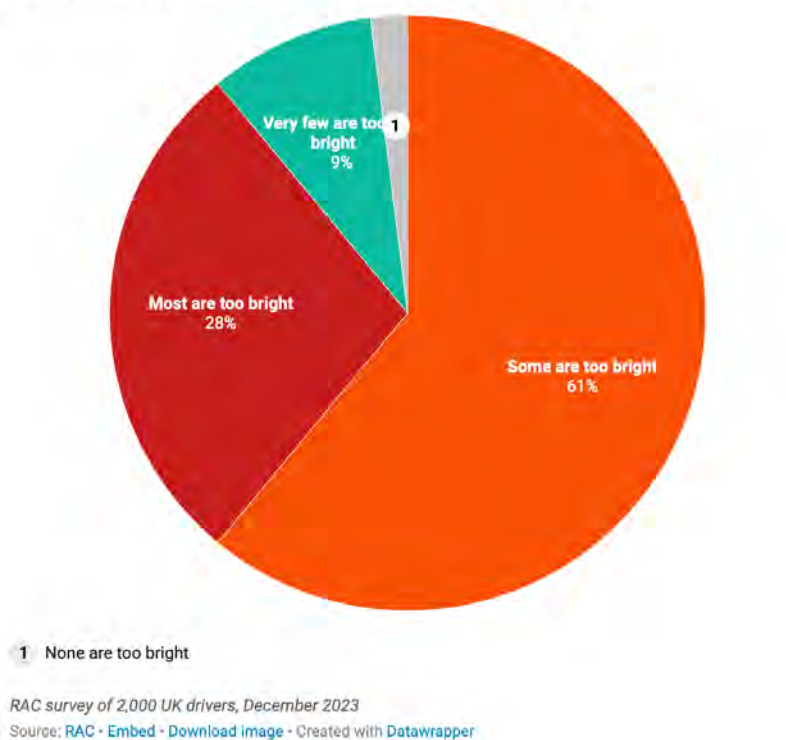


## Dazzling headlights: results from RAC research of UK drivers

Released January 2024

An RAC survey of 2,000 drivers found a huge nine-in-10 (89%) think at least some headlights on cars on the road today are too bright, of which three-in-10 (28%) – a higher proportion than ever – think most are. Of the all these drivers who complain about the brightness of car headlights, some 91% say they get dazzled when driving with three-quarters (74%) saying this happens regularly.

**Thinking about the brightness of headlights of cars that you see coming towards you on the road today, which of the following best describes your thoughts?**

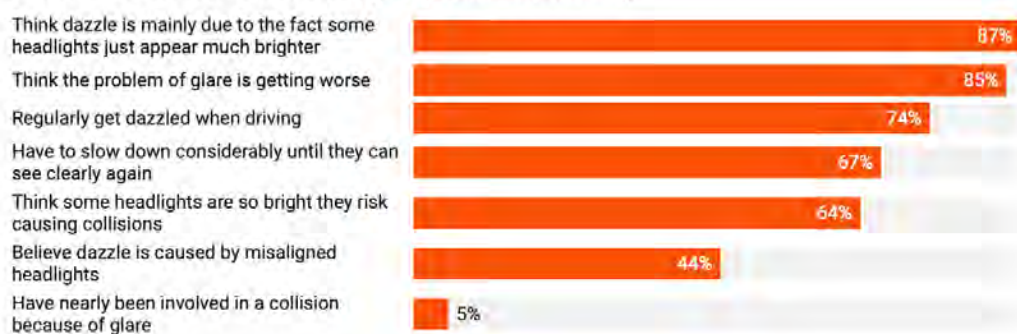


When it comes to the effects of glare on drivers, two-in-three (67%) who suffer say they have to slow down considerably until they can see clearly again, while a similar proportion (64%) believe some headlights are so bright they risk causing accidents. In fact, five per cent of these drivers state they have nearly been involved in a collision themselves.

Alarmingly, nearly one-in-10 (7%) say they find headlight glare so bad that they avoid driving at night altogether, a figure that rises to 14% for drivers aged 65 and over.

## Headlight glare - how are drivers affected?

Base: all drivers who are affected by glare (89% of respondents)



RAC survey of 2,000 UK drivers, December 2023

Source: RAC · Embed · Download image · Created with Datawrapper

While the RAC has been surveying drivers on dazzling headlights since 2018, these new findings show more drivers than ever appear to be suffering from them, with 85% of those affected stating they believe the problem is getting worse.

As part of its study, the RAC asked drivers to estimate how long it takes them to see clearly again after getting dazzled by other drivers' lights. While 68% say it takes between one and five seconds, one-in-10 (11%) say it takes six or more – which, staggeringly, is enough for a driver travelling at 60mph to cover 160 metres, the equivalent of 40 car lengths.

The reasons drivers perceive headlight glare to be such an issue are less clear, although an overwhelming 87% of dazzled drivers think it is mainly due to the fact some lights just appear much brighter. This could be as a result of the increasing prevalence of cars fitted with LED headlights, leading to a much more intense and focused beam that the human eye reacts differently to, compared to a conventional 'yellower' halogen bulb. While LED headlights are great for improving a driver's view of the road ahead, this can be to the detriment of other road users who encounter them.

However, more than four-in-10 (44%) think the dazzling is caused by badly aligned headlights. A Freedom of Information request submitted to the Driver and Vehicle Standards Agency (DVSA) in November 2023 shows that since 2019, an average of 1.6m, or 5%, of Class 4 vehicles – which includes passenger cars – failed their MOTs as a result of poor headlight aim.\*\* What's more, with the DVSA stating in 2016 that 'headlamp aim consistently tops the MOT compliance survey as one of the most likely items to be assessed incorrectly by testers', the actual figure could be much higher.\*\*\*

The increasing popularity of cars that sit higher on the road, especially SUVs, may also be a factor with those in conventional cars such as hatchbacks, saloons or estates suffering the most. Six-in-10 drivers (62%) of conventional cars blame the dazzling on higher vehicles, whereas only 35% of those in higher vehicles point the finger similarly sized vehicles.

But whatever the cause or causes of headlight glare, it is clear how strongly drivers feel about the issue with 81% saying more should be done to tackle it – a figure that rises to 87% among drivers aged 45 to 54.

Government collision statistics shows that since 2013, there has been an average of 280 collisions a year where dazzling headlights were a contributory factor. Of these, six a year involved someone losing their life.\*\*\*\* The actual number may be higher if an investigation was unable to determine whether or not a collision was directly or indirectly caused by the glare from another vehicle's headlights.

**As a result of the sentiment among drivers, the RAC has raised the issue of headlight glare with the Department for Transport and has been working with a member of the House of Lords, Baroness Hayter, to make drivers' concerns known among Government officials. The RAC provided details of its research to go into [a report provided to the Government](#). It welcomes a [commitment made by the UK Government in March 2024](#) to investigate the issue.**

**RAC spokesman Rod Dennis said:** "Our figures suggest drivers are more concerned than ever about headlight glare, with a huge proportion wanting to see something done about it. We urgently need the Government to take a closer look at the issue, ideally by commissioning an independent study to understand what's causing an increase in reports of dazzling and, most importantly, what can do be done to keep drivers safe.

"On the one hand, brighter headlights can be a good thing as they give drivers a clearer and safer view of the road view of the road, but that appears to come at a cost for those on the receiving end of excessively bright lights.

"The numbers of reported road casualties where headlight glare was listed as a contributing factor might be small when compared to something like speeding, but that only tells part of the story. Is it right we have such a high proportion of drivers who feel unsafe when they're driving at night, with some having even given up night-time trips altogether?"

**Mike Bowen, Director of Knowledge and Research at the College of Optometrists, said:** "The results from this research by the RAC are helpful to inform our understanding of how changes in vehicle headlight technologies may be affecting both the functional vision of young and older drivers, and their visual comfort, when driving at night. Older drivers are likely to be disproportionately affected by headlight glare, so may be more likely to experience difficulties or to decide not to drive at night at all.



**Baroness Hayter of Kentish Town said:** “The RAC has demonstrated that some car headlights can dazzle, causing a danger for oncoming drivers. We know drivers in other countries share this concern. So, government should take action now to be on the side of road safety and ensure everyone keeps to the Highway Code, which states drivers ‘must not use any lights in a way which would dazzle other road users’.”

## Ends

## Notes

\* Research conducted on RAC’s behalf by Online95 in December 2023 among 2,000 UK motorists, all of whom drive at least once a month. RAC first reported results of research into the issue in 2018

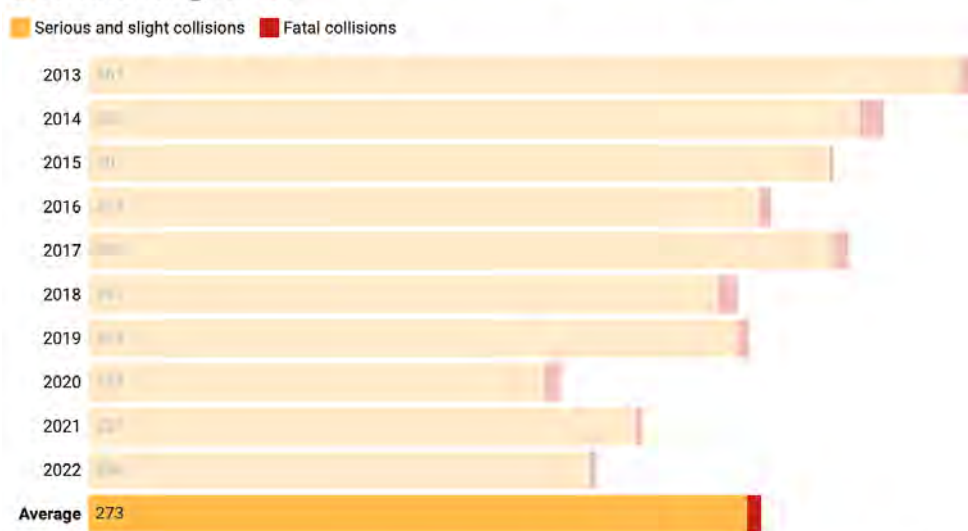
\*\* RAC FOI to DVSA, November 2023

\*\*\* <https://mattersoftesting.blog.gov.uk/the-mot-headlamp-aim-test-is-changing/>

\*\*\*\* See Appendix below

## Appendix

### Road collisions in the UK where dazzling headlights were recorded as a contributing factor



**Important:** Contributory factors are largely subjective and depend on the skill and experience of an attending police officer to reconstruct the events which led directly to the collision. [Read more on the strengths and weaknesses of the data](#)

Chart: Rod Dennis, RAC • Source: Department for Transport • Embed • Download image • Created with Datawrapper

## About the RAC

The RAC, an iconic UK brand, provides complete peace of mind to more than 13 million UK private and business drivers, whatever their motoring needs. As well as its premium nationwide breakdown assistance service – with an expert branded patrol workforce attending more than two million breakdowns every year – it offers a wide range of market-leading products across insurance, legal services, vehicle inspections and service, MOT and repair. The RAC is also at the forefront in helping drivers make the switch to electric vehicles and leads in the development of new solutions for businesses and OEMs, partnering with the best in the motoring and mobility space. Visit the [RAC website](#).

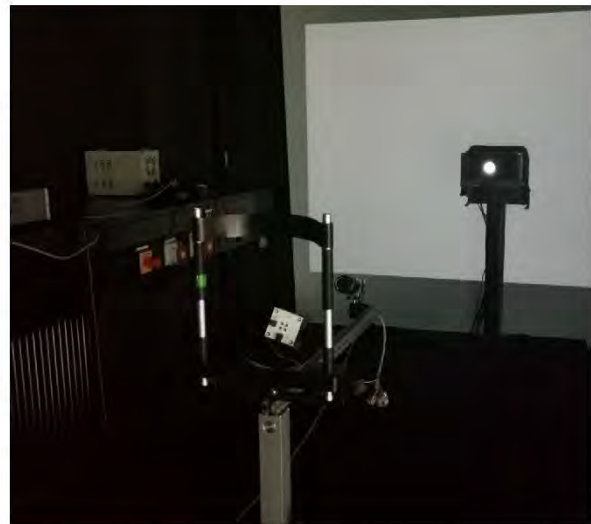
# Attachment E

Short summary of a study of TU Darmstadt on glare of ADB in clean and in dirty condition

# Lecture for the German Road Safety Council on headlight cleaning systems and current glare tests at the TU Darmstadt



Prof. Khanh, E. Kemmler M. Sc., Dr. Trinh, M. Peier M. Sc.



## Structure



1. Glare and headlight cleaning systems
2. Current glare tests (a brief presentation)



## Headlight cleaning system

### UNECE No. 48

- Spotlights with a luminous flux > 2000 lm
  - Headlight cleaning (SRA)
  - Automatic headlamp leveling (aLWR)



Performance	Lamp type	Luminous flux
55 W	H7 (halogen)	1500 lm
35 W	HID	3200 lm
25 W	HID	1900 lm
	LED	Depending on the design

- With the introduction of 25 W HID and LED modules with < 2000 lm
  - SRA and aLWR no longer mandatory!

## Headlight cleaning system

### How the SRA works

- **Pressure cleaning**
  - Washer nozzles spray a cleaning fluid onto the headlamp under pressure
  - **This requires a larger water tank and an additional pump = more space required**



- **Cleaning with windshield wipers**
  - Only possible with glass cover plates
    - Modern headlights are made of polycarbonate
      - and they scratch!
      - No smooth surface



## Headlight cleaning system

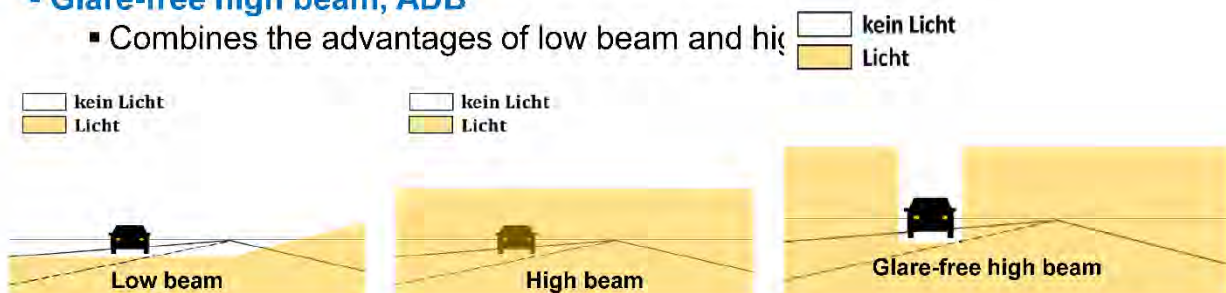


- Influence of pollution on the light distribution
  - Dirt particles on the cover lens scatter the light in all directions
    - Reduced visibility and therefore later detection of obstacles
    - Higher glare, e.g. for oncoming traffic due to stray light

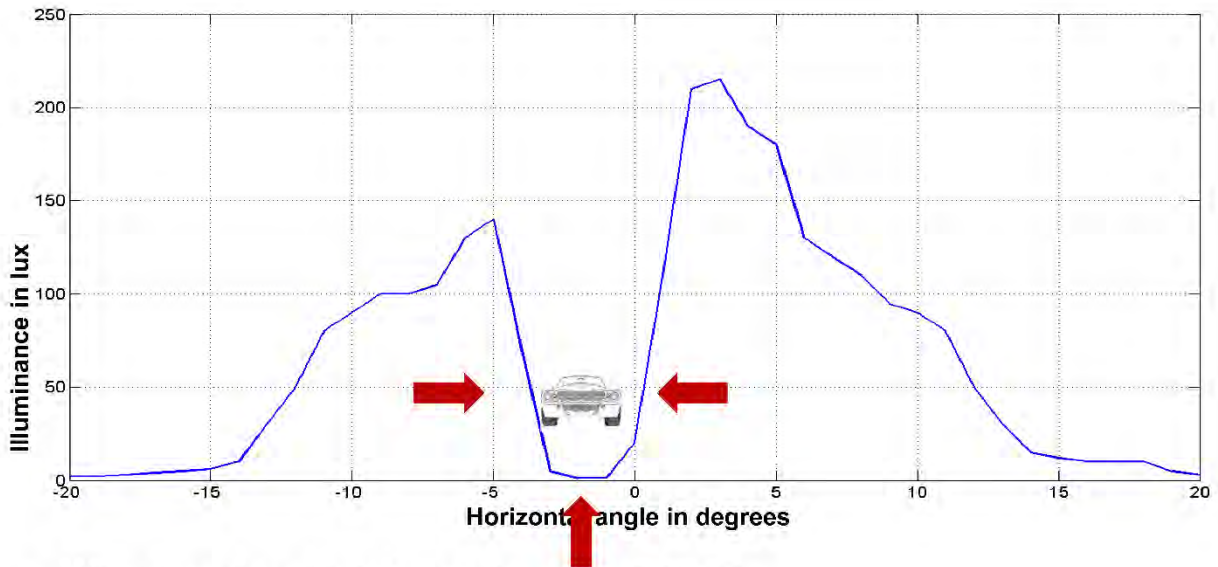
**Does the dirt really cause reduced visibility and increased glare?**

## Headlight light types

- **Low beam/sliding** headlamp range
  - Minimal glare with correctly adjusted headlights
  - **But:** low headlamp ranges and no illumination at the sides
- **High beam**
  - High headlamp ranges
  - **But:** Maximum glare → Not usable in traffic
- **Glare-free high beam, ADB**
  - Combines the advantages of low beam and high beam



# Headlight cleaning system



- With glare-free high beam there are 3 HDG  
→ More stray light to be expected in the "darkened area"?

# Headlight cleaning system



→ Light edges with scattered light occur with glare-free high beam systems

## Headlight cleaning system



### The first vehicle manufacturers are dispensing with the installation of headlamp cleaning systems

- Energy efficiency due to the lower weight
  - Cleaning fluid
  - Nozzles
  - Pump
  - etc.
- More space in the cramped engine compartment
- Reduction of costs

→ To what extent is safety on the road affected? (in terms of glare and visibility/detection)

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## Headlight cleaning system

### Literature overview



- **Lindae, Bosch, Germany 1968**
  - Headlight pollution leads to reduced visibility and increased glare
- **Rumar, Sweden 1974**
  - 60 % photometric loss leads to approx. 20 % lower visibility
- **Schmidt-Clausen, Germany 1978 & Van Laarhoven, Holland 1994**
  - *Glare illuminance increases with increasing pollution and then decreases again*

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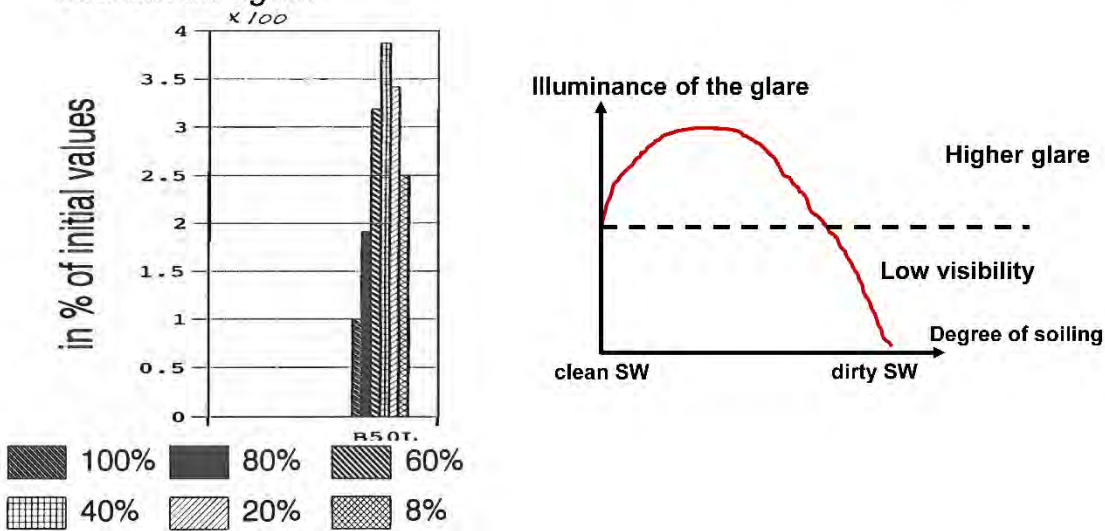
# Headlight cleaning system

Literature overview



## ▪ Schmidt-Clausen, Germany 1978 & Van Laarhoven, Holland 1994

- Glare illuminance increases with increasing pollution and then decreases again



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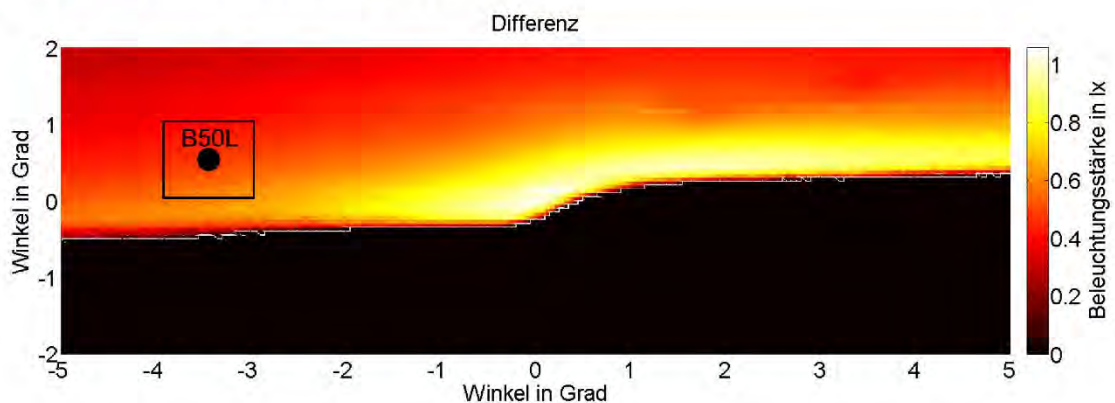
# Headlight cleaning system

Literature overview



## ▪ TU Darmstadt, 2016 (part 1) on the test site & Sivak et al., USA 1996

- less light below and more above the HDG



Mean and Std in B50L

Case	Mean	Std
Clean	0,2 lx	±0,01 lx
Artificially polluted	0,7 lx	±0,01 lx



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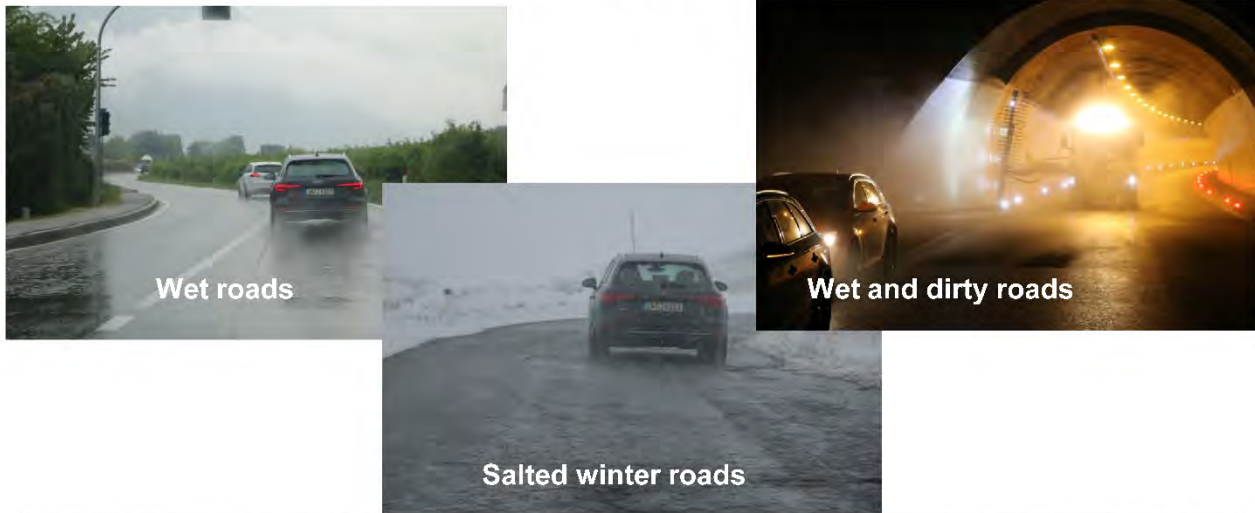
## Headlight cleaning system

Field test



### ▪ TU Darmstadt, 2016 (Part 2)

- 1200 km through the Alps
  - to contaminate the headlights with real dirt



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## Headlight cleaning system

Field test



### ▪ TU Darmstadt, 2016 (Part 2)

- 3 vehicles were examined
  - Halogen bulbs
  - HID
  - LED
- Every vehicle was equipped with the headlamp cleaning system
  - Although not mandatory for every vehicle
  - All headlights have been adjusted in accordance with ECE regulations
- **Key findings**
  - Highest SW contamination with salt-water mixture
  - Frequent measurements necessary to obtain "pollution curve"
  - Reproducibility

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# Headlight cleaning system

Field test

## TU Darmstadt, 2017

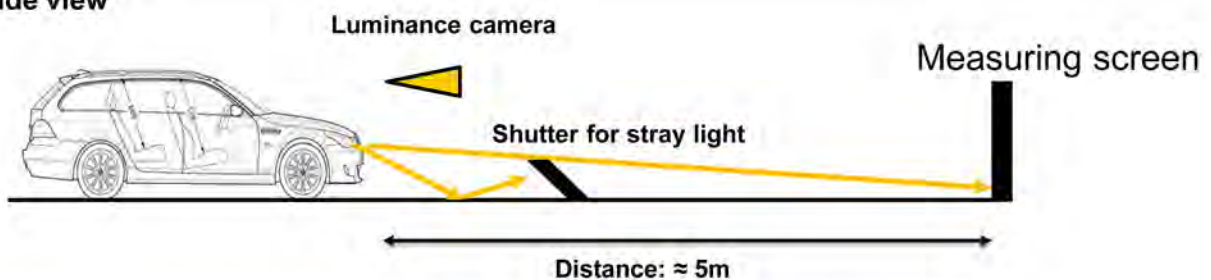
- Pollution measurement on a cordoned-off area
  - Circuit of approx. 400 m length
    - Reproducible measurements
    - Frequent measurements possible
- Circuit was watered and salt was spread



# Headlight cleaning system

Field test

Side view



## Advantage of luminance measurement vs. illuminance

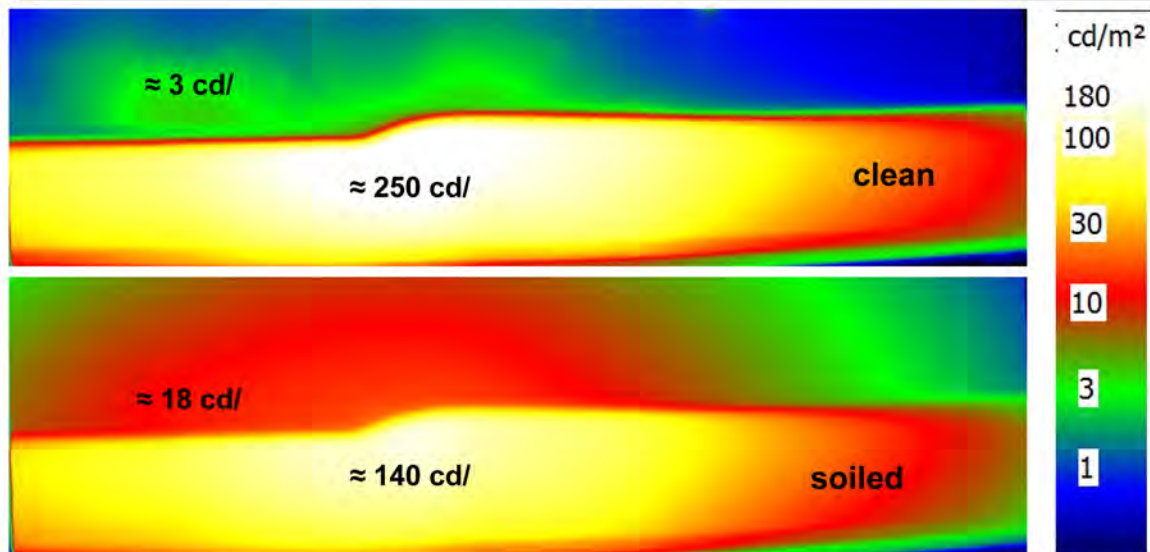
- Area measurement and no point measurement
- Conversion possible at any time by

$$L \rightarrow E =$$

with  $\rho$  = reflection coefficient of the screen

## Headlight cleaning system

### Results



### Influence of pollution on the light distribution of the cleaning system

- Above the cutoff-line: more scattered light → increased glare
- Below the cutoff-line: less light → lower visibility

## Headlight cleaning system

### Results

#### Clean

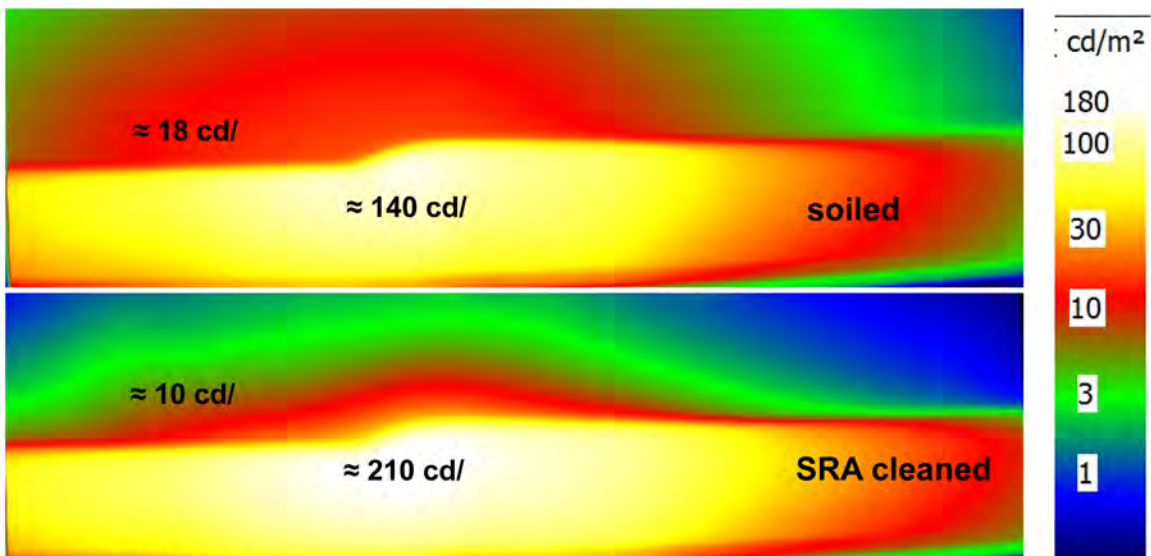
- $L = 3 \text{ cd}$  / at a distance of approx. 5 m  
→ = with  $E =$   
→ =  $0.5 \text{ lx}$  (see  $B50L$ )

#### Dirty

- $L = 18 \text{ cd}$  / at a distance of approx. 5 m  
→ =  $2.8 \text{ lx}$
- Due to soiling approx. factor 6 more illuminance for oncoming traffic  
→ Glare!

## Headlight cleaning system

Results

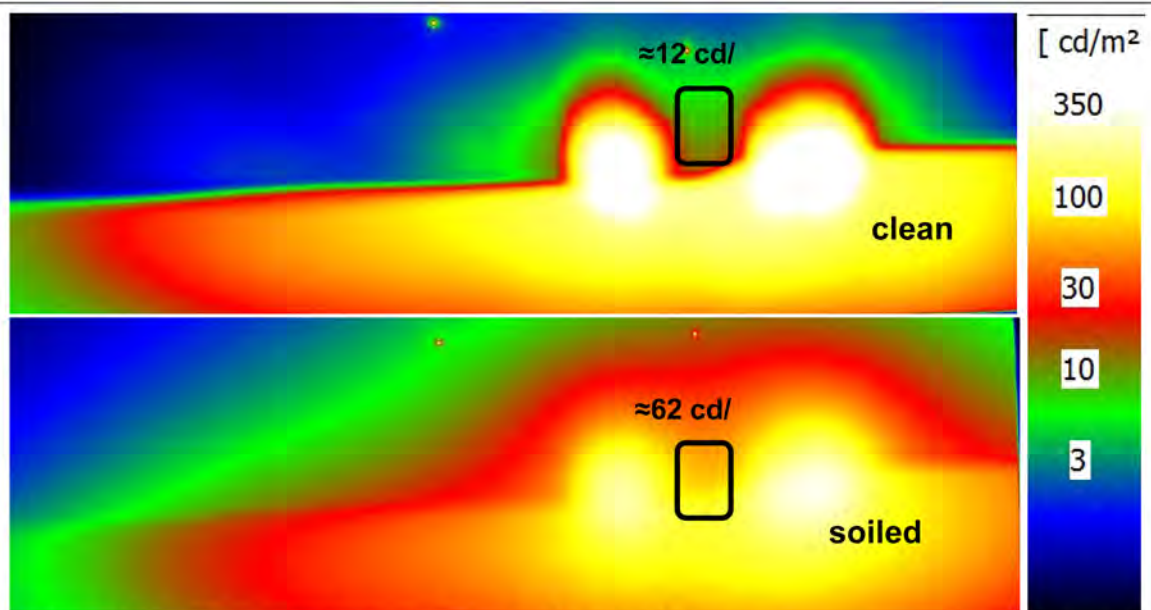


### Through SRA

- Less stray light above the HDG (**-55%**) → Less glare
- Brighter hot spot (**+50%**) → Higher visibility

## Headlight cleaning system

Results



### With glare-free high beam with 3 cutoff-line

- Stray light more than 3-4 times higher than with only 1 HDG (low beam)